THE GLASS INDUSTRY

VOLUME 30, NUMBER 6, JUNE, 1949

LATERAL GROWTH OF CUTTER MARKS IN GLASS

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Abstract

If glass is scored with a steel-wheel glass cutter, very thin fractures spread out parallel to the surface. If the fractures are viewed in monochromatic light, sharp interference bands are evident. The spreading of the fractures may be easily followed by observing the progress of the interference bands. Data are presented to show that the rate of propagation of such fractures is strongly dependent on the resistance of the glass to atmospheric attack.

I. Introduction

If a piece of glass is scored with a steel-wheel glass cutter and observed under a microscope using a monochromatic light source, interference bands are observed parallel to and emanating from the initial cutter marks. The interference bands move at various rates away from the cutter mark and indicate the propagation of fractures along the glass surface. A schematic cross-section diagram of a typical fracture is shown in Fig. 1. The fractures spread in the direction (a) and (b) away from the initial cutter position (0). This type of fracture was observed as early as 1920 by Dalladay and Twyman.[1] A diagram similar to Fig. 1 is presented by Jebsen-Marwedel and von Stoesser[2] and described further by Holland and Turner[3] and by Tammann and von Gronow[4] in articles which contain photographs showing the interference bands.

The factors influencing the growth of cracks in glass are as yet somewhat undefined. This investigation was conducted in view of the importance of the spreading of the fractures involved in the problems of cutting or fracturing of glass. The experiments were planned to study the effects of strain in the glass, glass composition and different atmospheres on the rate of propagation of the lateral cracks.

II. Method of Measurement

An ordinary steel-wheel glass cutter was drawn across glass with a medium pressure to produce the pertinent type of lateral fracture. The pressure must be suitable because too great a pressure caused a cracking-out of the glass in the areas above (a) and (b) in Fig. 1 and too little pressure prevented the formation of the fractures. At the moment of cutting, an interval timer was started. The glass sample was placed under the microscope and adjusted until the center of the cutter mark was located at the zero cross-hair or at position (0), Fig. 1. At one minute elapsed time, the distance from the zero position to the extreme edge of the last interference fringe (position (a) or (b), Fig. 1) was measured. By leaving the sample in the same position, the measurements were continued for the desired length of time.

The measuring scale consisted of a movable ocular micrometer with a total magnification in the optical system of 100X. A sodium light source was used to produce sharp interference bands.

III. Measurements on Commercial Glasses

The results of the spreading of fractures on some ordinary commercial glasses are given in Table I and are plotted in Fig. 2. The logarithmic scale was used for the time coordinate to straighten out the curves and permit better comparisons. It was found that variations in pressure on the glass cutter influence the initial width of the lateral fractures; therefore, the measured length of frac-

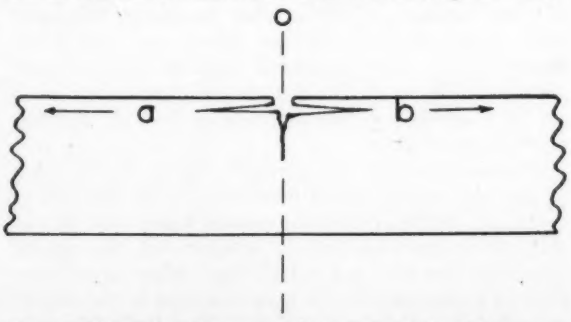

Fig. 1. Schematic diagram of fractures produced by a cutting wheel.

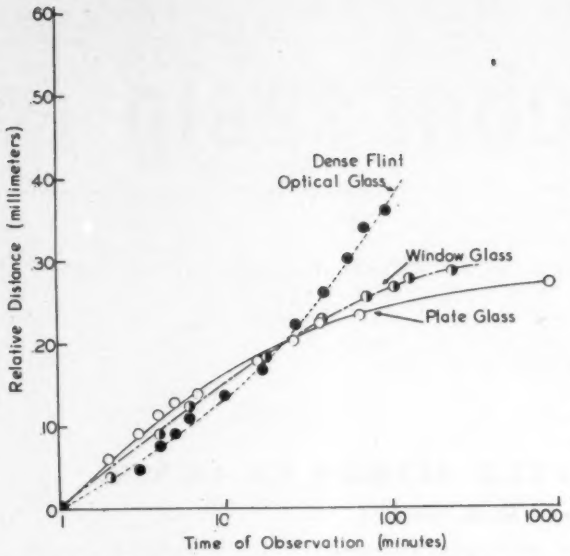

Fig. 2. The spreading of fractures in some ordinary commercial glasses.

ture data was placed on the same basis of zero millimeters at one minute elapsed time to produce a common origin for all the curves. The glasses were all commercially annealed.

TABLE I
Fracture Spreading Data for Ordinary Commercial Glasses

Window Glass		Plate Glass		Optical Glass	
				Dense Flint (N_D= 1.6169)	
Time min.	Distance mm.	Time min.	Distance mm.	Time min.	Distance mm.
1.0	0.000	1.0	0.000	1.0	0.000
2.0	0.039	2.0	0.061	3.0	0.046
4.0	0.094	3.0	0.092	4.0	0.083
6.0	0.125	4.0	0.116	5.0	0.094
17.0	0.182	5.0	0.129	6.0	0.112
38.0	0.228	7.0	0.140	10.0	0.138
77.0	0.258	16.0	0.179	17.0	0.171
105.0	0.267	28.0	0.206	27.0	0.226
130.0	0.280	38.0	0.226	40.0	0.261
235.0	0.287	66.0	0.234	56.0	0.304
		915.0	0.276	71.0	0.342
				95.0	0.364

IV. Effect of Strain

Since it is possible that the original strain in the glass might influence the spreading of the fractures, the rates of spreading of fractures on samples of plate glass with different amounts of strain were compared. Measurements were made on surfaces which were put either under tension or compression mechanically, on tempered samples which had the surface layer under much greater compression than the interior, and on commercially annealed glass.

The results, which are shown in Fig. 3, indicate that placing the surface under tension increased the rate of spreading. Since placing the surface under a slight mechanical compression had no influence on the rate of spreading, the data are not plotted. With larger compressive forces, as with the tempered sample, the rate of spreading was slightly diminished. The slight difference between the commercially annealed and highly tempered samples indicate that minor differences in annealing had no important effect on the spreading of the fractures.

V. Effect of Composition

Gurney[5] discussed the possible causes for delayed fracture of glass and concluded that atmospheric attack of the fresh surfaces explains the phenomenon better than other theories. Since the atmospheric attack is dependent on the glass composition, it is plausible that the propagation of the fractures would vary in different types of glasses. To test this theory, measurements were made on a few glasses of widely different durabilities in an effort to exaggerate the possible effect of durability on the rate of growth of the lateral fractures.

Commercial samples of fused silica and Pyrex brand chemical ware were selected for this purpose as well as two experimental glasses of particularly poor durability. The calculated compositions of the experimental glasses are given in Table II.

TABLE II
Calculated Compositions of Experimental Glasses Studied

	A	B
SiO_2	77%	80%
Na_2O	20	20
Al_2O_3	3	—

The curves showing the rate of spreading of the fractures for the various types of glasses are shown in Fig. 4. The spreading of the fractures on the glasses may be listed in increasing rate as follows: fused silica, Pyrex chemical ware, experimental glass B and experimental glass A. With the exception of experimental glass B the glasses would be listed also in approximately the same order of decreasing durability, thus indicating the interrelation between durability and the lateral growth of cutter marks in glass.

The fractures stopped spreading after 30 minutes in

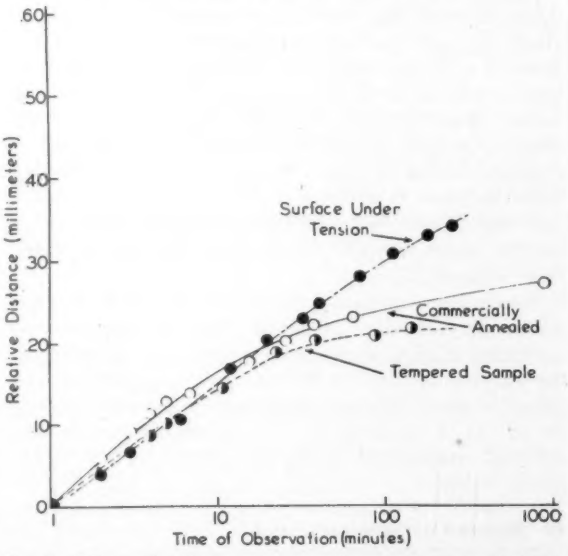

Fig. 3. Effect of strain on the spreading of fractures in plate glass.

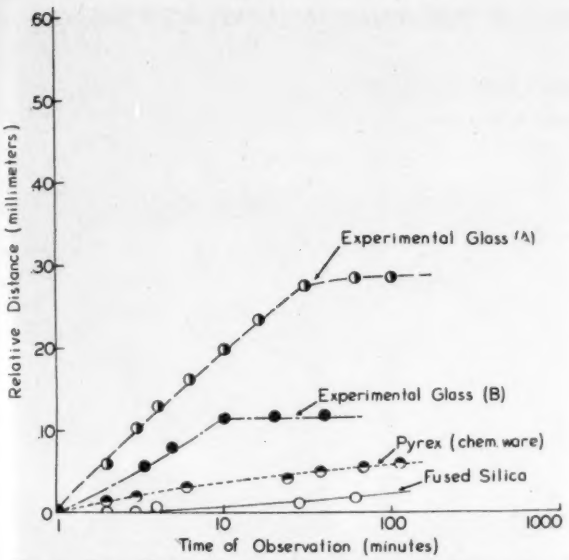

Fig. 4. Spreading of fractures in glasses of different durabilities.

the case of glass A and after 10 minutes with glass B. Microscopic examination of these glasses after the fracture stopped spreading revealed minute crystals at the apex of the fractures. The crystals seem to have greatly reduced the spreading of the fractures with experimental glass B and ultimately stopped the growth of the fractures in both glasses. The presence of the alumina in glass A had a decided effect in retarding the growth of the crystals, thereby allowing the fracture growth for this glass to continue for a longer period of time than for glass B.

VI. Effect of Atmosphere

Since it has been shown that the resistance of the glass to atmospheric attack greatly affects the rate of propagation of this type of fracture, a group of experiments was conducted to find the effect of certain gases and vapors some of which are known to act on glass surfaces. Water vapor, ammonia, carbon dioxide and acetic acid vapors were blown over the surface of commercial plate glass samples while the fractures were examined under the microscope.

Three decades ago, Hardy[6] found that acetic acid spread very rapidly on glass and this has been confirmed by several investigators since. It was not surprising therefore to find that acetic acid vapor increased the spreading rate of the fractures very decidedly, as is shown in Fig. 5. Possibly the spreading of the vapor over the surface weakens the glass bonds at the apex of the fractures, thereby permitting the fractures to spread at greater rates.

Carbon dioxide caused an increase in the rate of spreading of the fractures but after 85 minutes crystals formed at the apex of the fractures and the spreading stopped abruptly. The crystals may have been of the same composition as those experienced with the experimental glasses but the thinness of the fractures and the minute amount of material available for the formation of the crystals prevented them from growing to a sufficient size for a petrographic analysis.

The presence of water vapor over a sample increased the rate of spreading of the fractures. Ammonia also increased the rate of spreading but to a lesser degree.

Glass samples were placed in a chamber which was evacuated immediately after the cutter marks were made. The vacuum chamber consisted of a brass ring with glass plates forming the top and bottom to permit observations under the microscope. The glass plates were sealed to the ring with Silicone stopcock grease although a small amount of air leaked continuously into the chamber around the grease seal. The fractures on the samples treated in the chamber disclosed a slower rate of propagation than the samples exposed to air as shown in Fig. 5. After the vacuum pump was shut off, a sudden increase in rate was noted which may have been caused by the air starting to leak in.

VII. Summary and Conclusions

The rate of lateral growth of fractures arising from scoring a glass surface was shown to be dependent on the resistance of the glass to atmospheric attack by studying a group of glasses of widely different durability and by studying a single glass with varying atmospheres over the fracture. Stresses in the glass had a noticeable effect on the growth of such fractures, the rate increasing markedly when the glass surface was under tension and decreasing slightly when the surface was under pronounced compression.

With many of the samples studied, the growth of the fractures stopped abruptly after a variable length of time. Minute crystals were found at the apex of the fractures in every such case and it was thought that these prevented further growth of the fractures.

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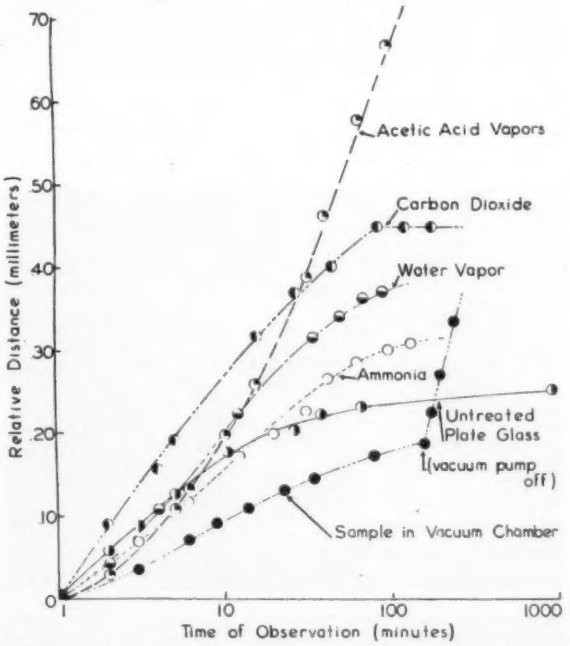

Fig. 5. Effect of various atmospheres on the spreading of fractures in plate glass.

SOME CURRENT METHODS OF GLASS DECORATING

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The decoration of glass or otherwise ornamentation of glass surfaces is not a new art. As a matter of fact, it is almost as old as the history of glass itself. Museum pieces and records testify to early attempts of glass artisans to further enhance the appearance of the handiwork of their craft. Suffice it to say, any decoration by whatever means achieved served no utilitarian purpose. On the other hand, the output of today's decorating departments is pretty well divided between the utilitarian and purely ornamental effects. In making this statement, the word "decoration" is used in the broad sense, that is, as it applies to any use of vitrifiable enamel, surface etching, cutting or engraving.

The big change in decorating procedure began in the early 1930s with the labeling of milk bottles with applied permanent lettering. These labels gave prominence to the name of the dairy, advertised some of its other products, and perhaps, through repetition, kept the customer visually conscious of the vendor's service.

Gradually, the bottlers of soft drinks began to adopt the applied color label. Not only did it serve to dress up the package but at the same time eliminated the nuisance of the paper label; the reapplication after each filling, and, resultant contamination of the ice coolers and vending machines. The net result of all of this has been to create applied color departments in most glass companies. The work of these departments has expanded tremendously so that today it has probably become the industry's largest secondary operation.

In further recognition of the practical aspects of applied decorations, mention may be made of such additional articles as a. Radio dials and panels; b. Pharmaceuticals (vials, ampules, etc.); c. Chemical glassware; d. Illuminating ware; e. Signs; f. Cosmetic containers; and g. Tumblers and tableware.

Paper presented before the Tenth Conference on Glass Problems, Ohio State University, Columbus, Ohio.

* Solar Engineering & Equipment Co., Beaver, Penna.

Operator placing bottle, previously printed with white background color, into Solar machine to receive second printed application. Movement of ware is from operator's right to left. Machine is driven by electric motor.

Solar decorating machine equipped with shoulder printing attachment. Screen stencil (a) prints shoulder of bottle simultaneously as screen (b) prints third and last color of body label. Colors are registered by lining up previously printed color with pointer (c). In the above picture, the operator has just removed the printed bottle and is in the act of inserting the next one in the ware holder.

Therefore, it can hardly be denied that the fused on decorations, either purely decorative or ornamental, have become a very important adjunct to the glass industry in general. And no small part of this greatly expanded program has been due to the progress which the various color manufacturers have achieved in producing vitrifiable colors or enamels of infinitely greater durability than was imagined possible only twenty years ago.

The Screen Process

Hand Operated. Of all decorating methods employed today, the screen stencil process is most widely used. More ware units are screen printed than are decorated by any other means. At first, production was limited to flat items, but later through the development of suitable hand operated equipment, the process was expanded to such lines as table tumblers, milk and beverage bottles, cosmetic jars, etc. A few hand operated machines are still in production. The daily output of this equipment is quite variable, and may range anywhere from 50 to 125 gross of ware per each 8 hour shift, depending on such factors as the size and shape of the article being printed, whether it is a first or second color application, and, of course, whether the machine is being operated by one or two persons.

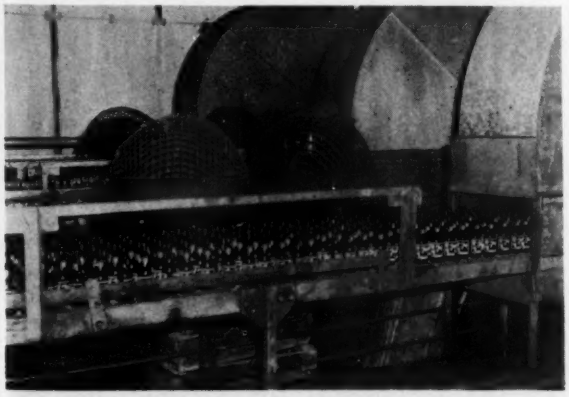
Gradually, the hand motivated equipment was either converted to or replaced by pneumatic or electric power operation. This reduced labor costs and in most cases, but not all, raised the daily production output. During the past three years, the Solar* semi-automatic decorating machine has experienced almost industry-wide distribution and acceptance.

This machine is motor driven and operates continuously on a fixed cycle basis. An operator is required to

Air driven bottle printing machine equipped with radius type shoulder printing screen.

place a bottle into the ware holder and remove it after printing. In the case of a two color printing job, it is also necessary for the operator to register the bottle in the second machine. These machines are equipped with suitable attachments for the simultaneous printing of the shoulder label while the first color body print is being applied. The machines are well engineered, smooth of operation and "easy" on screens.

It can readily be seen that the production efficiency and daily output of any semi-automatic hand-fed machine subject to hand registration will depend in an exceedingly large measure upon the skill of the operator. However, through experience gained by months of work on the production line, it is not uncommon to find good operators handling, on the basis of ware packed, an average of 100 to 120 gross of 7 or 12 ounce beverage bottles per each 8 hour shift, and at the same time registering colors within a maximum and minimum tolerance of $\frac{1}{32}$ of an inch. Nevertheless, at the top speed, and especially on labels of close registration, the misprints may average as high as 10 to 15%. These bottles are reclaimed and re-run, but even so, the problem of misprints represents a loss in color as well as the labor involved in printing and cleaning. Wherever or whenever the labor turn-over in an applied color labeling department is high, the resulting inefficiency is naturally productive of a higher percentage of misprints. Therefore, to help solve this problem, many manufacturers have resorted to the use of incentive systems, training programs and quite naturally, the transference to other departments those individuals who are either unsuited or unable to acquire speed and accuracy in a continuous repetitive movement.

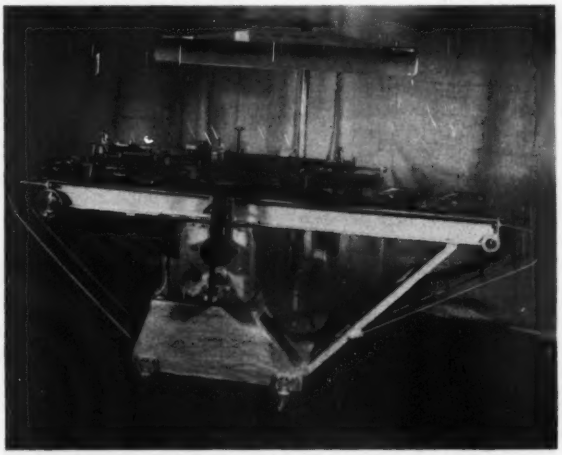


Three lines of printed bottles emerging from dryers enroute from first color printing machine (right) to second color printing machine (left). Dryers harden color print sufficiently well to prevent damage when subsequent prints are applied.

Automatic Equipment. In order to remove or at least minimize the factor of human error, a great deal of thought, time and money have been spent on the development of fully automatic equipment for the printing of beverage and milk bottles by the screen process. For milk bottles of both the square and round type, a few companies have made good individual progress.

One of the first machines developed for the automatic printing of square milk bottles was engineered by the Buck Glass Company. It was designed so as to print on one or all of the bottles' four panels. Although an automatic take-out was contemplated, manual unloading and transfer to the lehr is still employed in order to increase the machine's flexibility on small orders.

However, the only fully automatic machine designed for the printing of beverage bottles and now available, or in actual use for that matter, is the type SQA machine developed by the Owens-Illinois Glass Co., and recently made available to the industry in general by the Hartford-Empire Co., of Hartford, Conn. No official figures are available at this time as to the machine's capacity but it is generally understood that a daily output of 600 to 700 gross of bottles printed in 2 or 3 colors is possible in any 24 hour period.



Automatic printing machine for square milk bottles. *Courtesy Buck Glass Co.*

Machines are in use for the semi-automatic silk screen printing of table tumblers, but as much of the development work has been of a private nature, details of operation are not available for publication.

Types of Screen Stencils. Without taking the time to go into detail regarding methods of preparation, it is apropos at this point at least to make some mention of the various types of screen stencils currently being used.

Beverage bottles, almost without exception, are printed with metal mesh stencils, having a metal frame covered with 165 mesh stainless steel wire cloth on which a photosensitive film of polyvinyl alcohol has been applied.

Simple spray booth arrangement for handling low volume hand sprayed items. Note pressure regulator and air cleaner on the right.

Gelatine coated screens are still used to a limited extent, but these are less durable, prone to pin-hole, and are greatly affected by changes in humidity. Deterioration of gelatine stencils in storage is far more rapid than those coated with polyvinyl alcohol. Phosphor bronze wire and even copper may be used, but these metals lack the resiliency of stainless steel.

On the other hand, the gelatine film coated silk screen stencil is used almost exclusively for the printing of practically all other types of ware except beverage bottles. These screens are generally prepared by the carbon tissue method or by a direct deposit of sensitized gelatine sheets of .015 to .02 inches in thickness, on the silk mesh.

Carbon tissue is in reality a paper of good rag stock having a deposit of pigmented water soluble gelatine on one surface. Briefly, a screen stencil is made from it by first sensitizing in a potassium or ammonium bichromate solution and drying in the absence of light. Next, a film positive of the design to be reproduced is placed in contact with the gelatine surface and exposed to some source of actinic light, following which the wetted tissue is rolled face (gelatine side) down on a temporary support, generally polished copper. The whole is now immersed in hot water (115°F) and after the backing paper floats off, the design will appear with further washing in the hot water. To complete the job, the supported gelatine film is placed on a level surface, and the screen frame with the tightly stretched silk covering is now set down on the wet gelatine in which position it is allowed to remain until thoroughly dry. At this point, the screen usually pops loose from the temporary support carrying the gelatine coating with it.

Use of carbon tissue screens is confined chiefly to printing of flat surfaces, especially radio dials, instrument panels and silk screen decals. They give very sharp prints.

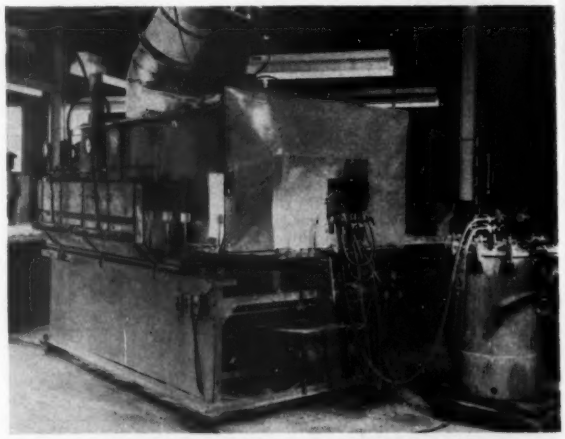
A gelatine sheet type stencil stands up better for the printing of round ware, and therefore is usually employed in the printing of milk bottles and table tumblers. The screens are processed by first coating the silk with a thin solution of a gelatine size. When this has dried, the screen is immersed in a weak solution of potassium dichromate, and the gelatine sheet floated into position over the silk gauze. Air bubbles and water blisters are smoothed out, and after the screen has dried, it is set in a printing frame over the positive and exposed. Unprotected portions are rendered water insoluble. Therefore, when the screen is developed out in the hot water bath, the unexposed portions wash away, leaving the open design through which the printing color will subsequently pass on to the ware.

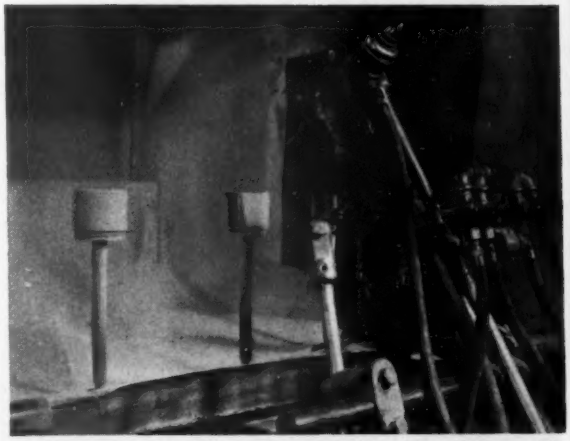
In both methods just discussed, use is made of the peculiar quality of colloids such as gelatine, glue, gum arabic, etc., to be rendered insoluble by dichromates in the presence of light.

Imported Swiss stencil silk either in half or full gauze weave is preferred over the taffeta weave. The twisted warp threads add extra strength to the stencil and prevent shifting of the woof threads during the printing stroke, especially if the silk is laid on the frame so that the printing stroke parallels the warp thread. The #12 standard full gauze stencil silk is the grade most commonly used.

The knife cut film stencils made from Nu-Film are still in use, especially in the making of screens for printing the larger signs, most of the bent panels for fluorescent light fixtures, and bent glass illuminating bowls.

Variations in Screen Printing. Multi-color effects are





a) Automatic spraying machine capable of handling a wide range of ware sizes. Baffle plates within the machine catch most of the overspray. Spray guns are attached to reciprocating mount which travels short distance with each item being sprayed, then swings back to cover next item. Note drying tunnel on left. From spray machine, ware is set directly into the decorating lehr.

b) Closeup of spray head mounting of automatic spray machine pictured in (a).

Girls clear lining kitchen light units. For decorative effect, the sprayed but unfired color is removed from the ridges on the all-over sprayed items.

achieved principally in the printing of table tumblers, Hi-ball glasses and cheese containers either through the use of a divided screen, or blended color work. By placing one or more dividers in the screen to separate the colors, two, three and sometimes four colors can be printed simultaneously with one squeegee stroke. Or, if it is preferred, the same number of colors can be applied in one operation by working only small quantities of each color on the screen at a time without the screen division. The result is a blended print. The colors do have a tendency to over-blend on the screen, and for that reason, an automatic color feed is quite advantageous.

Superimposed Printing. Most beverage bottles, flat signs and some bent glass illuminating units are printed with two or more colors. This is accomplished by selecting the proper squeegee oil for the color paste mixture so that after the first printed application has been made and dried, other colors may be overprinted. Thus, it is possible to print the ware with all required colors and follow up with one firing.

Squeegee Oil. The oil vehicle with which the ceramic color is mixed in order to prepare a paste mixture for screen printing is called squeegee oil. The complex, carefully compounded and blended squeegee oils used today are a far cry from the original linseed oil, rosin, and balsam of copaiba mixtures which were first used. Most manufacturers of squeegee oils now seek to use only the ingredients over which rigid controls can be maintained. For one thing, the oil must volatilize completely before any fusion of the vitrifiable color starts to take place. Furthermore, owing to the high lead content of the enamel, decomposition of the oil must not result in carbonization or any degree of reduction. Therefore, in brief summary, a good squeegee oil should have the following characteristics: 1) Volatilize completely before enamel fusing temperature is reached; 2) Provoke no blistering of the color; 3) Produce a color paste of sharp printing quality; 4) Produce a color paste which will not run after printing; 5) Produce a color paste which is unaffected by moisture; 6) Produce a color paste which will dry properly for second color application work; 7) Must be non-toxic for ordinary handling; 8) Should possess no objectionable odor; 9) Produce a color paste of good workability; and 10) Produce a color paste which will print sharply without showing screen marks.

Hand lining of light shades.

Spraying

The application of vitreous enamels, both colored and white, to various kinds of glassware by the spray method

Plate receiving band of liquid bright gold.

is the second most important decorating operation from the standpoint of volume. The spray gun provides a comparatively simple means of creating all-over color effects which could not be achieved by incorporating the color directly in the glass itself. It is a means of creating sales appeal and stimulating added customer interest in otherwise commonplace items. Consequently, expanded markets are now being found for such items as glass tableware, mixing bowls, refrigerator dishes, vases and cosmetic jars, all in glass, because such lines are being made more attractive by fired-on spray color.

Aside from the decorative value of color, white or tinted enamels sprayed and fired on flint glass illuminating ware has an important utilitarian value in light dispersion and soft illuminating effects.

Hand Spraying. The simplest spray set-up consists of a spray booth, spray gun, air pressure regulator, supply of color and a revolving turntable to support the glass.

An elaborate set-up is not necessary, but it is important to install such means of ventilation as will remove completely all spray fog so that none will be inhaled by the sprayer. If any single color is being sprayed for any

length of time, it is good economy to provide some means to collect and save the overspray. The simplest procedure involves placing a few baffles in the exhaust channel. Depending upon the labyrinth of baffles in use, one may save up to 90 or 95% of the overspray color. This is a substantial monetary recovery when it is realized that, on the average, only 60 to 70% of the atomized color actually adheres to the object being decorated.

Automatic Spraying. In order to handle economically a large volume of sprayed ware, an automatic spraying machine is indispensable. Good equipment, proven in production, is available which will turn out 300 to 500 gross of sprayed units per 24 hour day. Although loading and unloading is not automatic, production as mentioned above can be achieved with a minimum amount of labor. Ordinarily, two operators are needed to place the ware on the spindles, two to unload and transfer to the lehr, one for general assistance, and a supervisor.

Most automatic spraying machines are so designed that the ware is conveyed on spindles from the loading to the unloading position through the spray zone on a large circular track, or else the conveying chain follows a rectangular course. In either case, it is common practice to transfer the sprayed ware directly to the lehr belt at the farthermost point on the machine from where the application of color has taken place. This allows for a short lapse of time for air drying. However, it is preferable that the sprayed ware be passed through a short heated tunnel en route to the take off point. This short drying interval will usually evaporate enough of the spray vehicle so that the sprayed article may be grasped by the bare hand while being transferred to the lehr. This procedure makes for more rapid handling and eliminates the need for special ware forks or unloading tools.

Spray Color Vehicle. A number of years ago, turpentine was considered the basic spray medium or vehicle. Today, the amount of turpentine used is negligible in volume as compared to a water and alcohol mixture of approximately 3 parts water to 1 part alcohol. Isopropyl alcohol, denatured alcohol (such as synasol), and methyl alcohol are most commonly used although the use of the latter, owing to its extreme toxicity, should be discouraged.

Binding Medium. The average color, sprayed with a water/alcohol vehicle, drys to a somewhat powdery surface, and is quite easily scratched or finger marked prior to firing. Accordingly, certain binding or hardening on agents are added to the color mixture in small percentages. These agents reduce materially the chalky surface texture, binding the color to the ware sufficiently hard so that a direct hand contact with the surface will not show up as a blemish after firing.

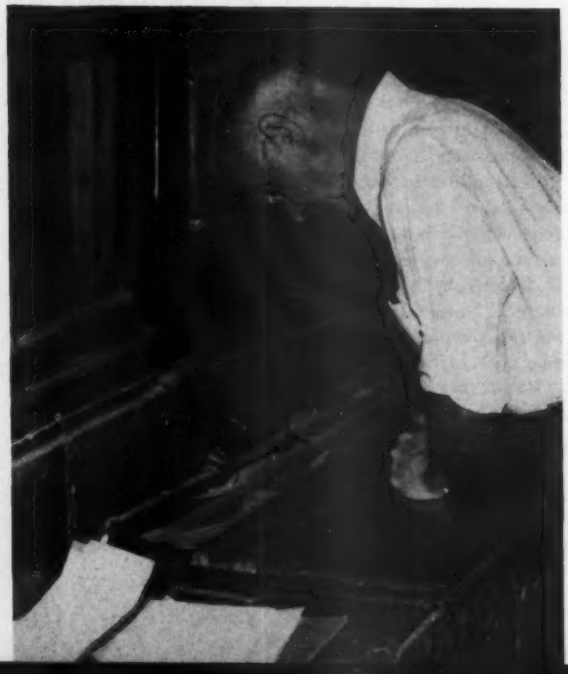
Reclaimed Color. The amount of color consumed daily by an automatic spraying machine makes it imperative to reclaim the overspray for economic reasons. Usually, a third of the sprayed color would otherwise be lost. Good machines are designed for this recovery by having all collecting chamber parts made out of stainless steel or aluminum in order to avoid contamination from rust.

All that is usually necessary to put the reclaimed color back into usable condition again is to simply stir in the required amount of vehicle and pass the suspension through a screening device known as a Rotospray. The rapid action of the Rotospray breaks up practically all of the particle agglomerous which have formed on drying, and in addition, screens out any contaminating lint, coarse particles of foreign matter, paper scraps, or whatever may be drawn into the spray collection chamber by the ventilating fan.

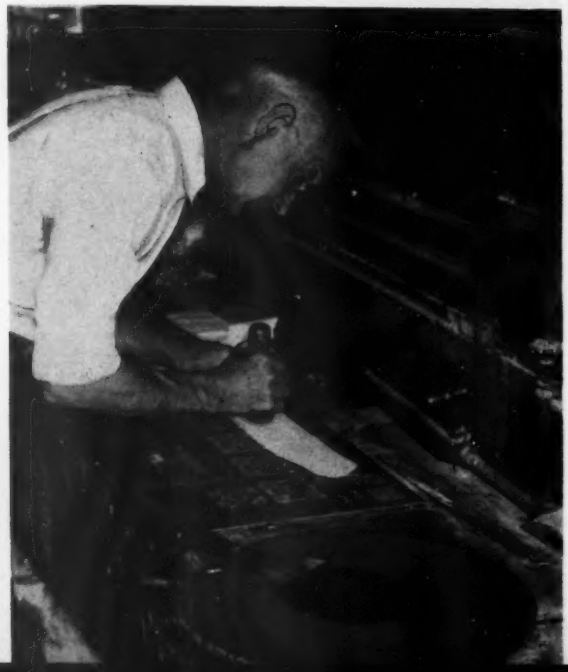
Other Decorating Methods

Banding and Lining. Hand banding and lining of glass with vitrifiable colors is one of the oldest methods of tumbler decoration. It is still practiced in unchanged form but to a very limited extent as the automatic banding and lining machine has all but replaced manual ap-

First stem in making transfer print from etched or engraved steel plate. Decorator in the process of scraping heavy paste printing color into etched portion of plate. Generally, a plate will have a number of designs etched into it as only certain areas are "worked" at one time.



Printing tissue, having been placed over the paste filled etched portion of the plate, is rubbed down into intimate contact by means of a rubbing brush. Large cast iron disk in the foreground is known as a printer's Baxton. It is on this that the color is mixed and kept warm while being used.



From the steel plate, the pottery tissue, which now is carefully pulled away, carries the color previously held in the etched area.

plication. Colors are applied by thin discs running in their respective troughs of color. The width of the band is determined by a transverse travel of the tumbler while the color wheels are in contact with the glass. Most banding machines can and usually do apply several colors without removal of the tumbler from the chuck.

Hand Painting. There are very few remaining decorators in the country today who have the skill to paint with ceramic colors the beautiful scenic views, portraits and reproductions of wild life which was their special forte three or four decades ago. Styles and taste have changed, and likewise, the demand for decorating so elaborately done. However, hand painting for the most part today consists in symbolic reproductions of floral patterns and adding color as a fill-in for certain types of silk screen prints. Most of the automatic banding is done with color mixed in a water base medium, whereas for all brush work gum turpentine remains the base oil.

Steel and Copper Plates. At one time, printing from an etched steel or copper plate was the fastest method available to the decorator. It is still the method most used by the potteries for printing underglaze colors. However, coincident with the development of the screen process, the transfer printing in the glass decorating shop was gradually replaced by the screen method. Not completely however, because the plate method is unrivaled for fine detail work and shading. Through several steps in progressive etching of the plate, that is, etching to variable depths, it is possible to obtain in one transfer print variations in color thickness. These variations in thickness of color deposit make it possible to add more character to the decoration.

Color paste for plate transfer printing must be of very stiff consistency in order that it will pick up every detail etched or engraved in the plate and also, not lose its sharp outline while being pressed into contact with the glass. Since most of these printing pastes are high in wax and venice turpentine content, the firing must be carefully and slowly done in order to avoid blistering and color reduction.

Bent Glass. For the production of the bent glass signs, canteen faces for gasoline pumps and convexed illuminating units, the use of vitrifiable enamel is indispensable. The colors are screen printed on the flat glass, usually double strength window glass, after which it is placed on a heavy sheet iron mold of the proper curvature and passed through a bending furnace. Convexing of the glass and firing of the color is, of course, a simultaneous action. The firing cycle is pretty much a function of time and temperature, and accordingly the bending furnace may be operated at temperatures ranging between 1200 and 1550°F.

Most of the canteen faces are printed with the design in as many colors as is required, after which the entire surface is given a light spray coating of white enamel.

In the case of the convexed illuminating bowls, the undecorated face is usually acid frosted to aid in light diffusion. To protect the fired-on enamel from the acid, that side of the glass is sprayed with a stripping lacquer which may be quickly and easily removed following the frosting operation.

Ice Decoration. A semi-rough, embossed decoration with a frosty appearance is obtained through the use of colorless granular low melting glass sized to approximately 50-100 mesh, called Crystal Ice. The glassware is first banded with a mixture of balsam of copaiba and turpentine or stamped with a tacky printing oil, after which the "ice" is poured over the tacky surface. Firing is carried out in the same way as for color. Colored "ices" are also used but only to a limited extent.

Other Fired-on Decorations

Among other decorative materials and methods involving firing, mention should be made of gold, lusters, amber (silver) stain and ruby (copper) stain.

Tissue is now usually cut up into easily worked sizes and placed with color side in contact with the ware to be decorated. Using the rubbing brush, color is worked into an all-over contact with the glass. Later, after the tissue has been moistened, the paper is easily stripped away. This act completes the decorating operation and the ware is now ready for firing.

Liquid Bright Gold is used more extensively than any other gold preparation. It is essentially a gold resinate, and when heated to the point of decomposition, a mirror-like gold film is precipitated. Adherence is sometimes improved by first "muddying" the glass. This is a term used to describe a preliminary procedure of applying and firing on to the glass an ochre-copper sulphate-iron oxide mixture which is subsequently washed off prior to decorating.

(*Continued on page* 350)

THE GLASS DIVISION AT CINCINNATI

For the first time at an Annual A.C.S. Meeting, joint sessions of the Glass and Refractories Divisions were held for the presentation of papers dealing with glasshouse refractories.

The 51st Annual Meeting of the American Ceramic Society and the 30th of the Glass Division was held in Cincinnati, April 24-28. There was no lack of hotel rooms. Food was excellent, as always in Cincinnati, and the weather was practically perfect.

It was unfortunate, however, that it again became necessary for the Society to schedule meetings of Divisions and other events in two different hotels. This arrangement made interviews difficult and interfered with the informal conversations and social gatherings which are such an enjoyable feature of these Annual Meetings. Moreover, and more importantly, it was very difficult for anyone to get from one Division to another to hear particular papers at the right time. The technical sessions of the Glass Division assembled in the Roof Garden of Hotel Gibson, whereas most of the technical Divisions met in the Netherland Plaza, and the Refractories Division in Hotel Sinton. The time spent in elevators and in footwork between the two hotels meant a good deal of waste.

Notwithstanding its seclusion, the Glass Division was well attended. An average of 200 persons were present during most of the sessions. Those who were more interested in the theoretical side of glass science had only to go to the Netherland Plaza to find the sessions on Physical Chemistry, in which a number of papers dealing with glass were presented.

Chairman Howard R. Lillie of the Corning Glass Works modestly relinquished the Chair to the Vice Chairman, C. H. Hahner, National Bureau of Standards, for two of the sessions, and to H. H. Holscher, Owens-Illinois Glass Company, the incoming Vice Chairman, for the Wednesday morning session. Incidentally, this relieved Howard and gave the new men some practice with the gavel. The joint session with the Refractories Division on Glasshouse Refractories brought out some excellent, practical papers, lessened the attendance at the regular Division session, and, incidentally, gave Howard Lillie another spot in which to preside.

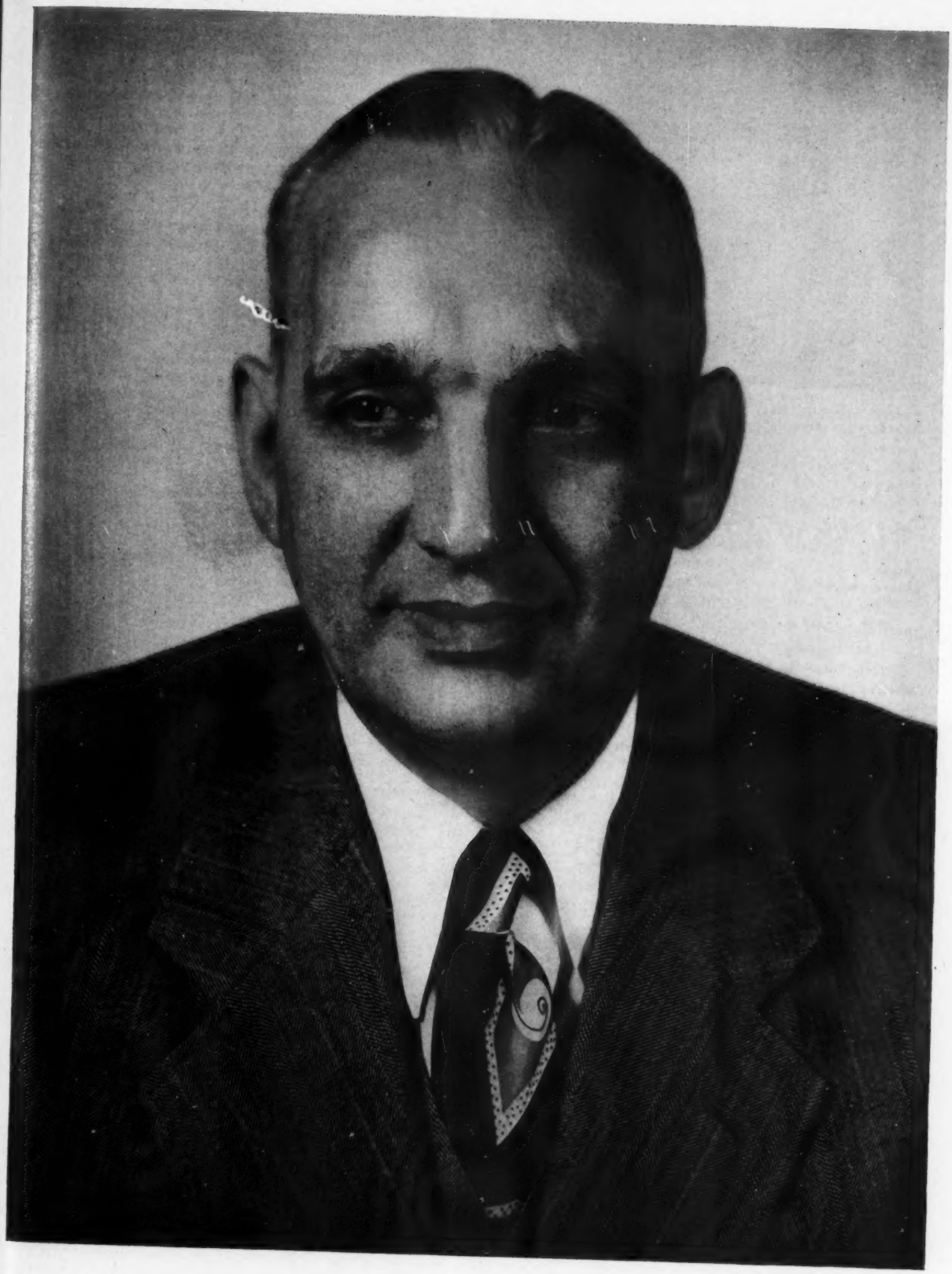
American Ceramic Society officers for 1949-1950, (left to right): Charles S. Pearce, General Secretary; W. E. Cramer, Treasurer; John W. Whittemore, Past President; Hobart M. Kraner, President; James W. Hepplewhite, President-Elect; Robert Twells, Vice-President, and Howells Frechette, Vice-President. Vice-President A. Lee Bennett could not be present.

New Fellows of the American Ceramic Society meet Past President Whittemore. (Left to right): J. E. Wiss, U. S. Gypsum Co.; Arthur Q. Tool, National Bureau of Standards; Kenneth M. Henry, Owens-Illinois Glass Co.; Roy C. Meeker, Kentucky-Tennessee Clay Co.; Clyde E. Williams, Battelle Memorial Institute; Harold E. Simpson, N. Y. State College of Ceramics; E. E. Marbaker, Mellon Institute; Lane Mitchell, Georgia Institute of Technology, and Professor Whittemore. V. C. Swicker could not be present.

For the first time in many years, the Vice Chairman was not in charge of program, which was in the hands of a special committee headed by F. L. Bishop, American Window Glass Company, who was aided by E. C. Hagedorn, Owens-Illinois Glass Company, and W. T. Gray, Leeds & Northrup Company. These men deserve a great deal of credit for getting together an excellent program, and for grouping the papers in such a way as to cause the least possible interference with the concurrent sessions on Physical Chemistry and Glasshouse Refractories. Abstracts of these papers are presented in another part of this Journal, so that no attempt will be made here to discuss individual papers.

Methods of presentation reflected the urging that has been put forth in recent years toward less direct reading of manuscripts, more legible slides and more opportunity for real discussion. Nevertheless, some authors still show a tendency to confine themselves to the manuscript, and some are still deluded with the idea that lantern slides made by photographing material in elite type make legible columns of data on the screen. A few still insist on reading for the audience all of the data on the screen, much as some customers in the days of silent movies read off the subtitles for the benefit or annoyance of their seatmates.

The luncheon on Wednesday was the only one held by the Division. A feature was the motion by Nelson W. Taylor, Minnesota Mining and Mfg. Co., placing the Division on record as regretting the absence of Frank W. Preston. Dr. Taylor prefaced his motion with a few friendly, uncomplimentary remarks about our absent



C H Hahner

Arthur S. Watts (left) receives his certificate of Honorary Membership from President Whittemore.

critic, which Frank would have enjoyed if he had been there.

At the business meeting on Wednesday afternoon, an interesting dilemma arose. The Chairman had pointed out that, through some editorial blunder in publishing the Rules in 1938, the passage of an amendment to the Rules seems to require the approval of two-thirds the membership of the Division. As a matter of fact, scarcely more than half the members ever return ballots, and thus none of the Rules changes made since 1938 have been properly carried. The Chairman of the Rules Committee offered the somewhat jaunty suggestion that he be permitted to make the necessary editorial changes, specifying that "two-thirds of the members voting" be required. This met with a somewhat surprising filibuster on the part of strict-constructionists, who came through with the equally jaunty proposal that an amendment to the Section of the Rules in question should be submitted to the members, accompanied by a letter stating that any member who did not return his ballot would be deemed to have voted for the proposal. Agreement was finally reached on an instruction to the Rules Committee to submit the problem to Keith McAfee, Chairman of the Society's Rules Committee.

The Fall Meeting of the Glass Division was announced for October 5-6 at Shawnee-on-the-Delaware, Pennsylvania.

Brief summaries of some of the papers presented before the Glass Division follow:

Study of Structure and Physical Properties of Some Boroaluminate Glasses. *By N. Chandappa and H. E. Simpson, Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y.*

A study of the properties of some boroaluminate glasses was made in order to ascertain the field of glass formation, and to determine physical properties of such glasses.

The field of glass formation in the system B_2O_3-Al_2O_3-Na_2O was first located. Then a series of glasses was made in which the sodium oxide content was replaced by alumina on a molecular percentage basis and boric oxide held constant. Physical properties were determined, such as expansion, viscosity, refractive index and density. The composition-property curves show deviations between 7.5 to 10 molecular percentage of alumina. It is believed that these deviations were caused by the change in coordination of boron. To verify this reasoning, 1% of sodium uranate was introduced in all the glasses considered in the property studies, and fluorescent spectra and transmission curves of these glasses were obtained. The results of these data indicated that the above reasoning was true.

A discussion is presented of the probable structure and change in structure of these glasses. Suggestions are also made for future work.

Investigations of the Structure of Glasses by Infrared Reflection Techniques. *By Scott Anderson, Anderson Physical Laboratory, Campaign, Illinois.*

The author has used the infrared reflection (and absorption) technique to investigate glass structure and surface structure changes with etching. In fact, by observing the changes in the reflection spectra upon etching the glasses, the author was able to deduce some ideas concerning the atomic arrangement of the original glass. It was the purpose of the discussion to present the reflection spectra of a number of glasses and to correlate these spectra with the structure of the glasses involved.

Following a review of the theory involved in the use of the infrared reflection method, three classes of glasses were discussed individually. The barium containing glasses are discussed first. The reflection spectra of these glasses show that barium enters into combination with silica in a definite and well defined way. Thus, the network of barium containing glasses is composed of SiO_4^{4-} tetrahedra and another structure (probably benitoite-like) as well. The last section showed that the network in Pyrex brand glass contains the silicate tetrahedron and at least one boron oxide structure.

In discussing the method, it was stated that the infrared technique appears to have promise as a tool to use in glass structure investigations, but that it is not the perfect probe. All conclusion concerning coordination are made by comparison with the spectra of crystals where the coordination is known from X-ray reflection data. Great care must be exercised to give proper weight to the effects occasioned by damping. At the present stage of development, it does not give the bond angles, strength or length. It does have an advantage in that it can be used for both reflection (for surface investigations) and absorption data. Its chief advantage is that it deals with actual atomic arrangements: the mass of the ions, their location with respect to one another and the forces acting between them and the surroundings.

Radioactive Tracer Methods Applicable to Ceramic Research. *By James R. Johnson, The Ohio State University, Columbus, Ohio.*

A brief non-mathematical survey of the basic principles of radioactivity and general physical and chemical properties of radio isotopes was given as a background. Instruments and methods for measuring the decay of radio isotopes and the practice of safety in radioactive tracer work was also discussed.

Several examples of how these methods can be adapted to both practical and theoretical studies of glass technology problems were given. In one, it was supposed that the contamination of a glass by its refractory container was desired quantitatively as a function of two or more variables such as temperature, time, glass composition or refractory composition. Specifically, it was supposed that it was desired to know the relative contamination by the iron in the refractory as a function of time of heating at a given temperature. A sample of the refractory would be exposed to neutrons (in the Isotope Pile at Oak Ridge) to convert the iron to iron 55 and iron 59. This refractory sample is then placed in the glass and subjected to the desired time-temperature conditions and suitable experimental conditions. Samples of the glass are then taken and the iron present from the refractory attack radio assayed.

In another hypothetical case, the rate and amount of volatilization of materials, such as lead, selenium, silicon, fluoride, sodium, etc., during the heating or firing of glasses was the process to be investigated. As a specific example, it was supposed that the loss of selenium from glass as a function of variables, such as time, temperature or glass composition, is to be studied. A small amount of radioactive selenium 175 would be mixed with the ordinary

selenium to be used in the test batch which would then be heated to the desired melting stages, removed and cooled. Samples of the glass would then be measured by a Geiger counter. In cases where the volatile material had a strong activity, such as sodium 24 or lead 209, a continuous counting of the flue gases might be accomplished.

The use of radioactive elements in industrial process control where the activity is far below the safety limits is a matter which should begin to receive serious consideration. A uniformly distributed activity could be made to actuate automatic controls by means of signals from an interpreting device, such as a Geiger counter. There are, of course, serious limitations to their use in this manner at present. Until greater familiarity with radioactivity is brought about, the danger of law suits from both employees and customers is always present. Glassware used in photographic work might possibly fog emulsions if, in some part of the glass fabrication process, long half life radioactive materials were used and became mixed into the glass. Radioactive elements in chemical glassware might conceivably interfere with its satisfactory use in controlled photochemical or biological processes.

Determination of Volume Expansion of Glass at High Temperatures. *By A. G. Johnson, S. R. Scholes and H. E. Simpson, Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y.*

The results of previous investigators on the volume measurements of glass at high temperatures have been quite limited. The work, however, of several investigators is presented.

A technique was developed for the determination of the volume expansion of glass at high temperatures. By the application of the Jolly Balance, the change in density of the glass with change in temperature was measured over a temperature range of 925° to 1300°C. The technique developed can be used only at high temperatures, but it was shown to give reasonably good reproducible results. From the data attained, it was concluded that glass has no discontinuity of properties as it cools through the annealing range. Suggestions for the improvement of the apparatus, as well as the improvements in the experimental technique were made. It was recommended that determinations of volume expansion over a temperature range of 500° to 900°C. be made in order to enhance and complete the results.

A Recording Dilatometer for Measurement of Thermal Expansion. *By J. C. Turnbull, Radio Corp. of America, R.C.A.-Victor Division, Lancaster, Pa.*

An automatic method of measuring thermal expansion with a relative accuracy of better than ± 0.5 per cent is desirable for the study and control of materials used in glass-to-metal seals. The equipment described by the author represents an attempt to obtain improved accuracy, together with simplified automatic recording, using a quartz-tube dilatometer. In this equipment, an improved method is used for holding the sample by means of a parallelogram of flat springs which minimizes the effects of uncertainty of contacts and friction forces. The measurement of expansion is obtained by the use of a resistance strain gauge in place of the conventional dial indicator. The voltage output of the resistance strain gauge may be measured on a potentiometer recorder such as is used for measuring thermocouple e.m.f. As the output resistance of the gauge is about 400 ohms, some types of recorders may not have sufficient sensitivity for this application.

The electrical circuit used was shown and indicated that the recorder chart records both expansion and temperature as functions of time for an arbitrary temperature cycle. From this chart, values of strain gauge output are taken off at a series of temperature values and the expansion per unit length of the sample is calculated and plotted.

The ability of this instrument to repeat data was determined by measurements taken on a single sample of a ceramic body over the temperature range 50-450°C. As a result, constant errors have been reduced to a small value and the standard deviation of 0.4 per cent which was found is believed to represent the reliability of the measurement.

Effect of Additions of Polyvalent Elements on the Surface Tension of a Simple Glass. *By C. R. Amberg, The N. Y. State College of Ceramics, Alfred, N. Y.*

This research was undertaken in the hope that a surface tension study of concentration series of polyvalent elements in a simple glass would help to give understanding of the relative strengths of bonds in the glass and lead to a better understanding of the structure of glass and of forces of non-noble ions.

After reviewing previous work and methods, the maximum bubble pressure method was selected for this work on surface tension. The molecular composition of the base glass used was $Na_2O \cdot 2.22\ SiO_2$. Additions replaced equivalent molar quantities of the glass. With two exceptions, these additions were made in 0.001, 0.01 and 0.05 mol. fractions. The ions of V, Cr, Co, Ni, As, Mo, Sn and Pb, as well as the phosphate and sulphate ions, were used in the base glass.

To summarize the results briefly, it was shown that: when the oxides of Ha above polyvalent elements (except Co) are introduced in low concentration in a sodium silicate glass, the surface tension of the glass tends to be increased, the effect being greater at the lower temperature. With higher concentrations of the oxides of the same elements, the surface tension tends to fall from the maximum attained with low concentrations. It may or may not fall below the surface tension of the base glass.

Of the elements investigated, only cobalt shows no evidence of a maximum in the surface tension concentration curves at any of the temperatures studied.

The elements studied have in common the ability to exist in different states of valence, at least one of which possesses neither the eight electron outer shell of the noble gases nor the eighteen electron outer shell of the B subgroup. The author believes this last mentioned non-noble character is involved in surface tension reduction.

A satisfying theory of the cause of the maximum in the surface tension concentration curves has not been constructed, at least partially because of insufficient information on the states of oxidation of the various elements in glass; the coordination with oxygen corresponding to those states of valence; and the structural relationships of the coordination groups in glass.

The author believes that surface tension studies open a field that can give much information on the structural relationships and bond strengths of the various components of glass but that a large amount of study will be necessary to arrive at a complete understanding.

The Effect of Addition of ZnO on Properties of Soda-Lime-Silica Glasses and Methods of Introducing it into a Glass. *By A. R. Khan and H. E. Simpson, Dept. of Glass Technology, N. Y. State College of Ceramics, Alfred, N. Y.*

Zinc oxide, when used in glasses, is known to contribute desirable and unusual properties; however, certain limitations must be recognized: material costs are high, there are melting difficulties as well as devitrification and opalescence when large amounts are used and segregation and sticking of the raw batch during mixing may occur. The present investigation, therefore, had two objectives, the primary one being the study of the effect of zinc oxide on glass properties and the secondary one being the study of methods of introducing ZnO into the glass.

Zinc oxide was substituted for SiO_2 in a base glass of composition SiO_2-75%, Na_2O-16% and CaO-9%. Substitutions were made in intervals of 2% up to a total of 20%. Physical properties including the softening point, thermal expansion, density and chemical durability were then determined. Beneficial results were noted up to 10% ZnO and confirmed the work of other investigators. Beyond 10% substitution, the resistance to attack by acid decreased and the thermal expansion increased slightly. The maximum obtained at 16% ZnO in the case of softening point and chemical durability suggests that the glass undergoes a definite reorientation of structure at this point and it is probable that a zinc silicate is formed in the glass.

With glasses high in zinc, it was found very advantageous to flux the zinc prior to melting with B_2O_3. By adding zinc

as a zinc borate, two distinct advantages were realized: 1) the raw batch was easier to mix and 2) the time required to melt and fine the glass was reduced considerably.

Decomposition of Glass by an Acid Leaching Solution. *By G. E. Lorey and H. E. Simpson, Department of Glass Technology, New York State College of Ceramics, Alfred, N. Y.*

A method was studied for determining the rate of release of the soluble elements in a glass to an acid leaching solution. The measurement of the durability of glass does not involve the true solubility of the glass but rather the rates of reaction and the selective solution of ions from the glass. It was hoped that this information would reveal more clearly the mechanics of the decomposition of glass and also serve as a measure of its durability.

An acid leaching solution (0.02N HCl) was run through a column of powdered glass at a temperature of 50°C. Soda and silica removed from the silica gel on the surface of the glass were determined gravimetrically. It was found that the soda and silica were present in the extractions in a ratio (SiO_2:Na_2O) greater than a sodium metasilicate relationship and less than the amounts present in the original glass. By successive analyses of the leaching solutions, curves were obtained showing the rate of removal of soda and silica. With progressive leaching, the reaction slowed down to a constant rate, probably because of the adsorbing power of the increasing silica film. Determinations were made on three glasses typical of those used in the flat-glass industry. One was a plate glass and the other two were window glasses.

Pure Research on Glass in the University of Pittsburgh. *By Alexander Silverman, University of Pittsburgh, Pittsburgh, Pa.*

Chemical fundamentals and scientific principles have been applied in glass research in the University of Pittsburgh for half a century. For example, in 1902 the application of fundamental principles enabled the author to reproduce alabaster glass. This experience led to work on electro-conductivity of dissolved salt in molten glass and other work on ions in glass.

Other basic work includes studies of the cause of color in selenium-ruby glass, oxidation-reduction equilibria in glass between iron and selenium in several furnace atmospheres, opal glass researches, alumina-silicate relationship in glass which established the fact that the aluminum atom can replace the silicon atom in the random lattice in glass, tantalum glasses, effect of iron on fluorescence in glass, glasses for absorbing X-rays and gamma rays.

At the present time, this policy of basic research is still being carried out and at the moment work is under way in the department on neutron-absorbing glasses.

A Study of the Adherence of Molten Glass to Heated Metals. *By J. A. Kapnicky, H. V. Fairbank and W. A. Koehler, West Virginia University, Morgantown, W. Va.*

The purpose of this investigation was to study the adherence of molten glass to heated metal under conditions of temperature and motion similar to those found in automatic forming machines used in the glass container industry. The procedure used, in brief, was to allow drops of molten glass (2000°F ± 50°F) to fall upon a sample of the metal being investigated, said metal surface being inclined at a 45° angle. At the start of a test, the metal was heated to 400°F and its temperature increased until a drop of the glass exhibited a noticeable delay before rolling off the metal. When this point was reached, the metal temperature was increased by 100°F and its heating coil turned off. Beads of glass were then dropped on the metal as it cooled and the highest temperature at which no hesitation could be detected was recorded as the "critical temperature."

Several cast irons, a number of non-ferrous metal and alloys, the effects of a carburizing, nitriding, annealing, cyaniding and quenching, the effects of the degree of polish of the metal surface and the effect of commercial mold lubricants were studied by this procedure.

From the results obtained, it was concluded that: 1) the highest critical temperature obtained was 650°F for the stainless steels and for pure aluminum. The east irons tested had critical temperatures, in general, at about 600°F ± 25°F with no relationship between critical temperature and carbon and silicon content being apparent. The lowest critical temperatures were of the order of 500°F, these being obtained for a chromium-nickel-tungsten alloy and for pure titanium.

2) The effects of the various treatments used on the metals were, with the exception of the lubricants, to lower the critical temperature. The average lowering of values for the treatments was 75°F for carburizing, 100°F for cyaniding, 113°F for nitriding, 142°F for annealing and 100°F for quenching.

3) An increase in degree of polish of the metal surface raised the critical temperatures from an average of 425°F to an average of 625°F for the samples polished on No. 1 and 3/0 polishing paper, respectively.

4) All the mold lubricants evaluated caused a rise in critical temperature. An increase of 200°F was obtained by the application of a graphite suspension in oil.

Effects of Radiant Heating on Glass Working Production and Equipment. *By H. K. Richardson, Westinghouse Electric Corporation, Bloomfield, N. J.*

All glass working operations after the melting and fining must take into consideration the strain and annealing points of the glass and the annealing operation has developed into a long time- and space-consuming job. Theoretical deductions indicate that time and equipment need be only a fraction of that in current use. To approach this theoretical, each individual piece of glass must be assured the same treatment. Such a situation is met by the use of radiant heating methods.

Examples of current industrial application were given to show the use of ceramic, gas-radiant burners in glass working processes. These included annealing glass-to-metal seals, exhausting metal-glass tubes, a controlled short-cycle lehr and lens dropping.

Four types of radiant burners were described: the open fire type, the nest type for roofs and hearths, the continuous trough type and the nozzle mixing type for very large capacities. General characteristics of radiant burners include 1) The rate of heat release is governed by the quantity of mixture delivered (i.e., the burner head pressure applied and the burner size); 2) The heat transfer from burner to body being heated is instantaneous since the burner temperature is over 1700°F.; 3) The temperature in front of a burner varies inversely as distance of object from burner and is not subject to the sharp drop found in regular flames where the drop from focus to mantle is over 2000°F. in a short distance of less than ½ inch; 4) The effectiveness of the burner is different in the open or enclosed work. For instance, a burner that in the open will take 40 inches burner head pressure will in an enclosure take 80 inches pressure and therefore have 41 per cent more mixture capacity or BTU release; 5) The products of combustion must leave the cup as they are burned. This sting-out is invisible when perfect combustion takes place at the rated capacity of the burner; 6) The greatest heat is in direct line of center of burner when the object is placed beyond the dark effect of the burner tip.

Radiant heating has the following advantages for heating of glass: 1) The ceramic cup permits the release of large quantities of BTU/hr. from a small area. For example, on burner releases 500,000 BTU per hour in 105 sq. inches; 2) Provides radiant heat whose relative rate of heat release is high and since the temperature of the burner ceramic is over 1700°F., the heat is instantaneously transferred from cup to object; 3) The radiant cup allows the heat to be directed or patterned.

Glass Research at the A.S.H.V.E. Laboratory. *By G. V. Parmalee and W. W. Aubele, A.S.H.V.E. Laboratory, Cleveland, Ohio*

The extensive use of glass in modern buildings has emphasized the need for sound data on heat flow through glass areas. The American Society of Heating and Ventilating

(*Continued on page* 359)

THE SPECTRAL-TRANSMISSIVE CHARACTERISTICS OF SOME GERMAN GLASSES

By RALPH STAIR, FRANCIS W. GLAZE and JOSEPH J. BALL

Department of Commerce, National Bureau of Standards, Washington, D. C.

Abstract

In this paper are given the compositions and the transmittances for the ultraviolet, visible and infrared of 31 glasses of German manufacture. They vary in color and characteristics and in intended application. Many have American counterparts available on the open market. Some have especially interesting transmission characteristics, which render especially useful their study in connection with experiments upon glass spectral filters as a function of their composition.

I. Introduction

The history of the manufacture of glass for various purposes indicates that it has been singularly free from sudden and radical changes in basic composition. Although the developments in modern glassmaking have been carried on with a considerable amount of secrecy among laboratories, the final products usually follow similar patterns; e. g., it has been found that only within certain limits of composition are soda-lime-silica glasses stable and practical. The addition of other metal or earth oxides simply changes the color or other characteristics of the glass to a degree depending upon the amount and kind of oxide added. We therefore do not expect too much new information from the study of German glasses. There are, however, among these glasses certain compositions and characteristics which are interesting.

Many of the data on composition and transmittance herein recorded are available in the Publication Board report by C. H. Hahner[16] or in the Jena filter glass catalogue.[17] Since these publications have been limited in circulation and do not contain transmission data beyond the water absorption region,[2, 15] a more complete presentation has been prepared covering the wavelengths above 2800 millimicrons. The data on chemical composition in Table 1 were obtained from members of the staff of the Schott glass works at Jena. The values given represent the composition of the batch materials before the melting operations.

The spectral transmittances for wavelengths longer than about 2700 millimicrons are affected greatly by the amount of water present.[2, 15] It was found by measurements made by one of the authors (R.S.) in 1935 that the absorption in the region of 2900 millimicrons may be made to vary within wide limits simply by controlling the amount of water in the glass. Little is known about the melting conditions pertaining to these glasses and their effect upon the water content of the various samples.

II. Instruments and Methods

For purposes of presentation the illustrations are divided into two groups; the ultraviolet, visible, and near infrared spectrum below 900 millimicrons, and the complete spectrum including the infrared region extending to the long-wave cut-off of the glass. This division allows the ultraviolet and visible portions of the spectrum to be plotted on a greatly expanded wavelength scale.

For wavelengths shorter than 1000 millimicrons the measurements were made by the point-by-point method using a Beckman Quartz Spectrophotometer.[7, 8] For the longer wavelengths three different instruments were employed. In the region of 1000 to 1850 millimicrons an all-quartz double monochromator employing a photosensitive surface (or a thermopile) was used. Readings were made by both a recording arrangement employing a modulated light source, tuned amplifier and Speedomax recorder, and by the point-by-point method. For the spectral region extending from 2000 millimicrons to the long-wave transmission limits of the glasses, a Baird automatic infrared recording spectrometer[9] was employed. Additional readings between 1800 and 2500 millimicrons were made by the point-by-point method with the fluorite-prism mirror spectrometer and auxiliary equipment previously used in much of the infrared transmission measurements on glass at the National Bureau of Standards.[2, 10]

III. Spectral-transmittance Data

The various tints of glasses result from the kind and amount of colorant added to the base glass. The color may be caused by one or more absorption bands cen-

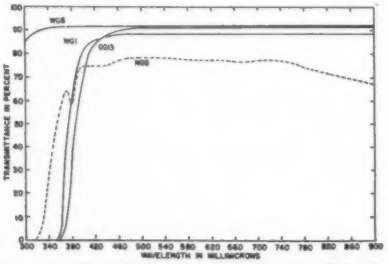


Fig. 1. Spectral transmittances of WG-8, t = 1.95 mm; WG-1, t = 1.78 mm; GG-13, t = 2.00 mm; and NG-8, t = 1.04 mm.

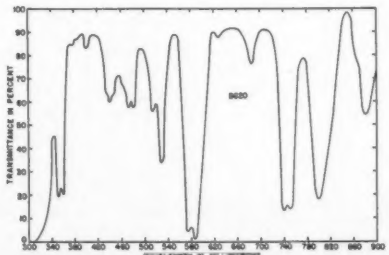


Fig. 2. Spectral transmittance of BG-20, t = 2.05 mm.

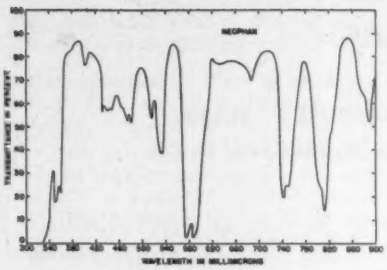


Fig. 3. Spectral transmittance of Neophan, t = 1.83 mm.

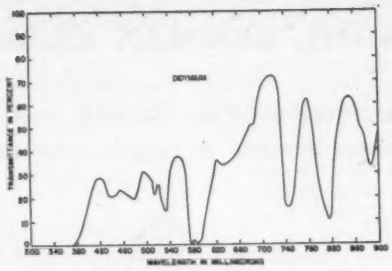


Fig. 4. Spectral transmittance of a Didymiun glass, t = 1.95 mm.

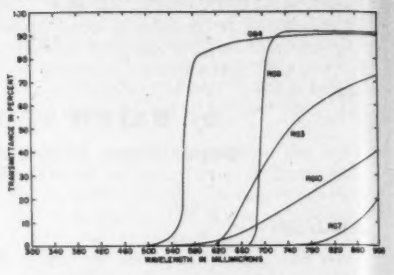


Fig. 5. Spectral transmittances of OG-4, t = 2.05 mm; RG-8, t = 1.98 mm; RG-3, t = 2.05 mm; RG-10, t = 2.02 mm; and RG-7, t = 2.04 mm.

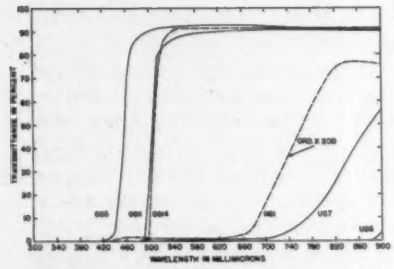


Fig. 6. Spectral transmittances of GG-5, t = 2.05 mm; GG-11, t = 2.07 mm; GG-14, t = 2.02 mm; NG-1, t = 1.04 mm; UG-7, t = 2.01 mm; and UG-6, t = 2.04 mm. The ordinate for NG-1 is multiplied by 200.

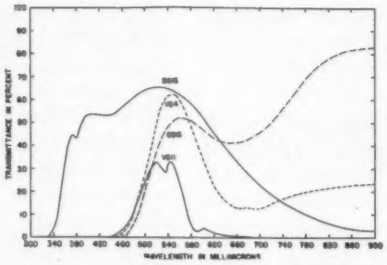


Fig. 7. Spectral transmittances of BG-16, t = 2.05 mm; VG-4, t = 2.05 mm; GG-16, t = 2.02 mm; and VG-11, t = 2.00 mm.

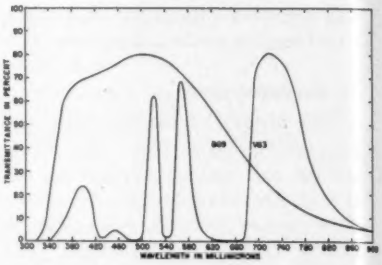


Fig. 8. Spectral transmittances of BG-9, t = 2.05 mm; and VG-3, t = 1.90 mm.

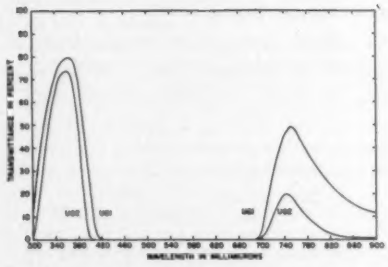


Fig. 9. Spectral transmittances of UG-1, t = 1.00 mm; and UG-2, t = 2.04 mm.

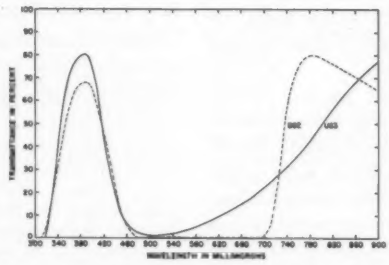


Fig. 10. Spectral transmittances of BG-2, t = 1.99 mm; and UG-3, t = 2.00 mm.

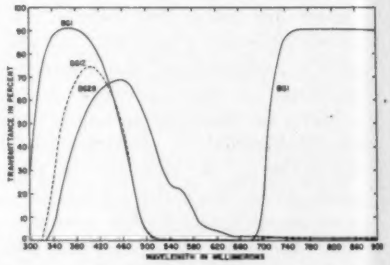


Fig. 11. Spectral transmittances of BG-1, t = 2.04 mm; BG-12, t = 2.02 mm; and BG-28, t = 1.03 mm.

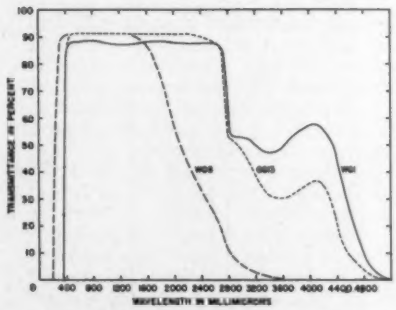


Fig. 12. Spectral transmittances of WG-8, t = 1.95 mm; GG-13, t = 2.00 mm; and WG-1, t = 1.78 mm.

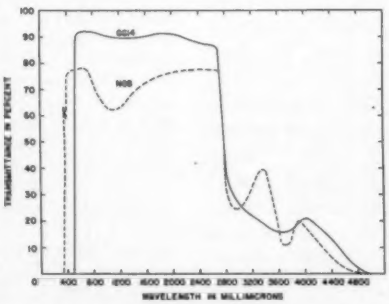


Fig. 13. Spectral transmittances of GG-14, t = 2.02 mm; and NG-8, t = 1.04 mm.

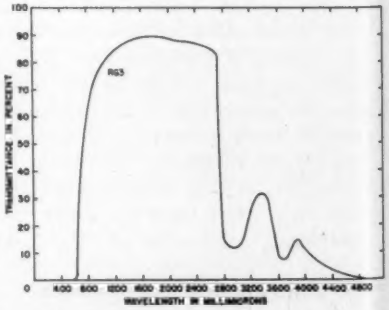


Fig. 14. Spectral transmittance of RG-3, t = 2.05 mm.

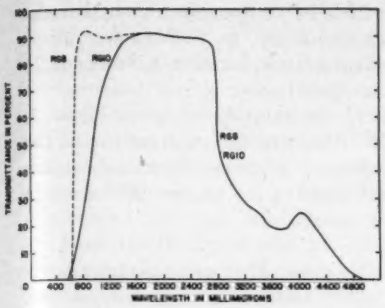


Fig. 15. Spectral transmittances of RG-8, t = 1.98 mm; and RG-10, t = 2.02 mm.

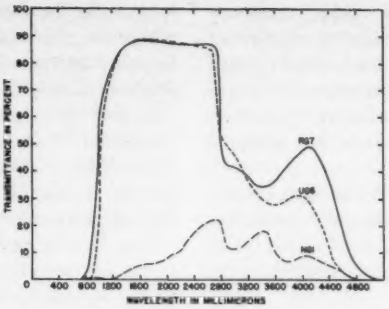


Fig. 16. Spectral transmittances of RG-7, t = 2.04 mm; UG-6, t = 2.04 mm; and NG-1, t = 1.78 mm.

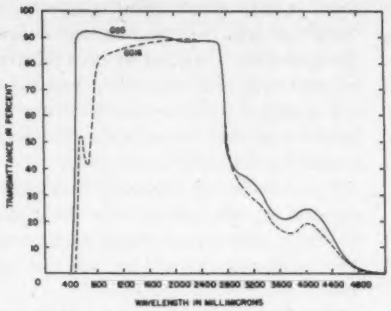


Fig. 17. Spectral transmittances of GG-5, t = 2.05 mm; and GG-16, t = 2.02 mm.

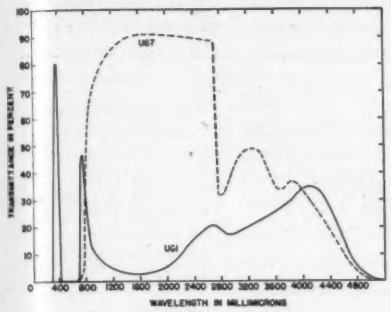


Fig. 18. Spectral transmittances of UG-7, t = 2.01 mm; and UG-1, t = 1.00 mm.

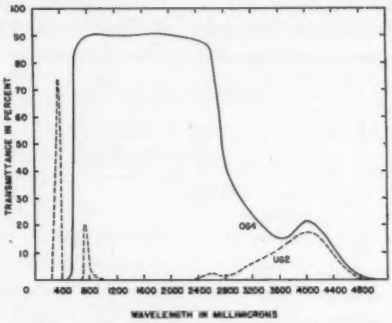


Fig. 19. Spectral transmittances of OG-4, t = 2.05 mm; and UG-2, t = 2.04 mm.

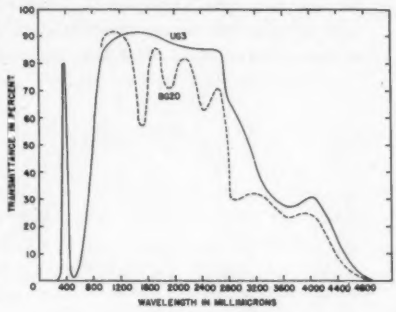


Fig. 20. Spectral transmittances of UG-3, t = 2.00 mm; and BG-20, t = 2.05 mm.

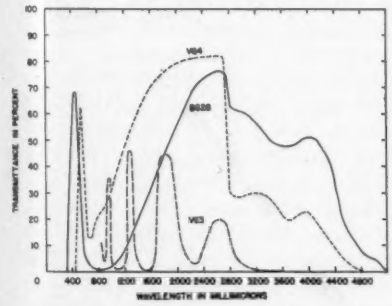


Fig. 21. Spectral transmittances of VG-4, t = 2.05 mm; BG-28, t = 1.03 mm; and VG-3, t = 1.90 mm.

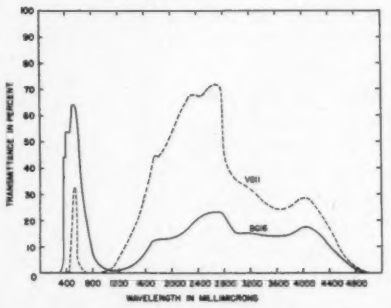


Fig. 22. Spectral transmittances of VG-11, t = 2.00 mm; and BG-16, t = 2.05 mm.

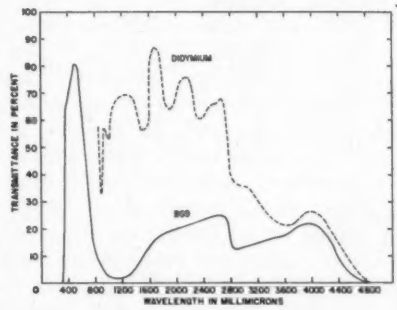


Fig. 23. Spectral transmittances of a Didymiun glass, t = 1.95 mm; and BG-9, t = 2.05 mm.

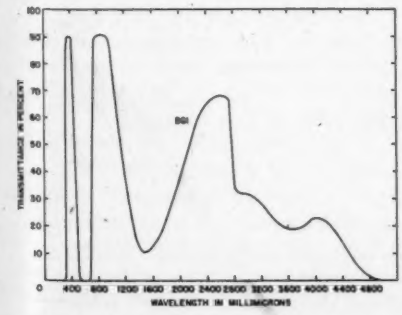


Fig. 24. Spectral transmittance of BG-1, t = 2.04 mm.

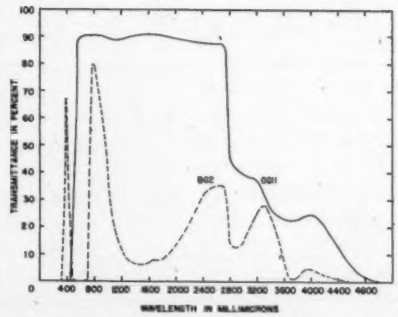


Fig. 25. Spectral transmittances of BG-2, t = 1.99 mm; and GG-11, t = 2.07 mm.

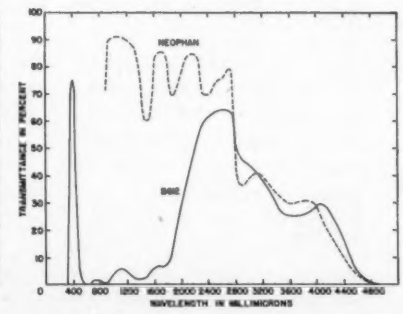


Fig. 26. Spectral transmittances of Neophan, t = 1.83 mm; and BG-12, t = 2.02 mm.

tered within the visible spectrum, or within either or both the near ultraviolet and near infrared regions of the spectrum. Neutral or near neutral shades are formed by materials having either general absorption throughout a major part of the spectrum or else many narrow bands scattered through the visible region, for example caused by the didymium oxides.

For simplicity, in the discussions, the various glasses covered in this report are classified largely according to hue; colorless, amethyst, neutral, red, yellow, etc. The compositions of the various glasses are given in Table 1.

The infrared spectral transmittances of these glasses are apparently modified mostly through the addition of iron, cobalt, nickel, copper and some of the rare earth materials, but are also influenced by the choice of the base glass. The addition of selenium, cadmium, sulfur and some of the other materials which produce the dark red glasses have but little effect upon the infrared transmittances. The green chromium, as well as the yellow cadmium-sulfur-selenium glasses, likewise have but little selective absorption in the infrared.

1. Colorless glasses. In this discussion a glass is classed as "colorless" if there is no apparent tint in the glass when viewed through a single thickness not exceeding about 2.0 millimeters; for greater thicknesses a distinct color may be observed.

The three glasses, GG-13, WG-1 and WG-8 (see Figs. 1 and 12) belong to this class. They are especially interesting in view of their wide range in composition. GG-13 is a lead glass colored slightly yellow through the addition of a small amount of cerium oxide. It is similar in transmittance to that of Cruxite A[5]. WG-1 is a high lead glass and illustrates the increased transmittance obtainable in the ultraviolet through the omission of the cerium and in the infrared beyond 3000 milli-

Table 1. Composition of the Glass Batch

Filter No.	SiO_2	B_2O_3	Al_2O_3	Na_2O	K_2O	CaO	ZnO	BaO	PbO	As_2O_3	P_2O_5	KHF	Coloring Materials and other Data
	(Parts by Weight)												
UG-1	59.2	2.0		1.0	17.0		20.0			0.3			3.5 Ni_2O_3, 1.0 Co_2O_3
UG-2	71.2	1.0	2.0	14.3		11.4				0.1			4.5 Ni_2O_3, 0.9 Co_2O_3
UG-3	50.0			1.0	13.1				35.5	0.4			3.0 $KMnO_4$
UG-6	65.1	1.5		6.0	12.4		3.0		11.0	1.0			7.0 MnO_2, 4.0 $K_2Cr_2O_7$
UG-7	75.5	5.0	3.5	6.4	2.2			5.0		0.5			4.0 MnO_2, 2.0 $K_2Cr_2O_7$
BG-1	65.5	2.0			19.8	12.0				0.3			0.4 Co_2O_3
BG-2	73.8	14.5	1.5	0.5	6.0				3.0	0.5		0.5	1.5 Co_2O_3
BG-9	70.0	2.5	1.0	12.0	4.5	6.0	4.0						1.0 FeO Melted in reducing atmosphere
BG-12	70.0			9.8	10.0		10.0			0.2			1.4 CuO, 0.45 Co_2O_3
BG-16	70.0	2.5	1.0	12.0	4.5	6.0	4.0						1.9 FeO Melted in reducing atmosphere
BG-20	53.5	4.0		16.0				6.5					20.0 Lanthan-Didymoxyd**
BG-28	70.0			9.8	10.0		10.0			0.2			3.2 CuO, 0.11 Co_2O_3
VG-3				3.0				25.0		0.3	71.0		11.0 $Na_2U_2O_7$
VG-4	62.3	10.0		8.9	8.5				10.0	1.0			0.2 CuO, 0.95 $K_2Cr_2O_7$
VG-11	58.0	2.5		9.0	9.5		5.0		15.0	1.0			1.1 CuO, 1.15 $K_2Cr_2O_7$, 8.5 Lanthan-Didymoxyd**
GG-5	61.1	3.9		1.0	18.6	13.8							0.5 CdS, 0.5 S Melted in reducing atmosphere
GG-11	62.0	4.0			20.0	14.0							1.25 CdS, 1.0 S
GG-13	55.3			3.5	6.9				33.3				1.00 Sb_2O_3*, 3.9 CeO_2
GG-14	51.7	3.9			22.5		19.5						1.7 CdS, 0.15 Na_2SeO_3
GG-16				No data									
OG-4	51.7	3.9			22.5		19.5						1.7 CdS, 0.2 Na_2SeO_3
RG-3	70.0	15.0	4.0	10.0	1.0								0.4 Cu_2O Melted in reducing atmosphere
RG-7	41.1			1.0	1.0				51.0	0.5			10.0 MnO_2
RG-8	51.7	3.9			22.5		19.5						1.1 Cds, 1.4 Na_2SeO_3
RG-10	53.8	4.0			22.0		20.0			0.2			0.5 CdSe, 0.75 CdTe
NG-1	60.5	19.0	1.5		12.1		4.0					4.9	9.0 Fe_3O_4, 0.43 Co_2O_3 Melted in reducing atmosphere
NG-8	60.5	19.0	1.5		12.1		4.0					4.9	1.4 Fe_3O_4 Melted in reducing atmosphere
WG-1	35.8			2.0	2.5				55.2	0.5			4.0 TiO_2*
WG-8			5.0		3.7			11.0			80.3		
Neophan					No data								
Didymium					No data								

* Not coloring oxides.

** Lanthan-Didymoxyd is a mixture of lanthanum, praseodymium and neodymium oxides of unkown composition.

microns when a part of the silica is replaced with additional lead oxide[14]. WG-8 is a phosphate glass (above 80 percent P_2O_5) and has a high ultraviolet and visible transmittance, being more transparent than any of the silica glasses in the ultraviolet spectrum. In the infrared, however, the transmittance falls to an inappreciable value for wavelengths exceeding about 3600 millimicrons. This glass is not stable under normal atmospheric conditions but develops a frosted surface as the result of its high hygroscopicity. It is similar in transmittance to the Corning Corex A glass[4].

2. Amethyst glasses. Two glasses, BG-20 (Figs. 2 and 20) and UG-3 (Figs. 10 and 20), may be included under this classification. BG-20 contains lanthanum and the didymium oxides (neodymium and praseodymium) which produce the numerous absorption bands shown by the transmittance curves. It is a light amethyst glass similar to didymium glasses produced by American manufacturers[5]. UG-3 is a lead glass to which a sufficient amount of $KMnO_4$ has been added to give it a dark amethyst color (Fig. 10). From about 500 millimicrons the transmittance increases gradually with wavelength until at 1300 millimicrons and beyond it becomes practically that of a colorless lead glass.

3. Neutral glasses. NG-8 (see Figs. 1 and 13) is a good example of a light neutral shade glass resulting from the melting of a zinc borosilicate crown glass containing Fe_3O_4, in a reducing atmosphere. This glass has the characteristic FeO absorption bands at 380 and 1100 millimicrons. Other glasses ranging toward neutral are the didymium glasses, BG-20, Neophan and Didymium (see Figs. 2, 3, 4, 20, 23 and 26). Neophan appears to have somewhat the same base glass as BG-20. Didymium glass appears to be a potash-lime-silica base glass. In all of these glasses the main colorants are the didymium oxides, neodymium and praseodymium. BG-20 (already discussed under amethyst glasses) and Neophan appear to be almost identical in spectral transmittance, except that Neophan is slightly darker in shade and is more nearly neutral than BG-20 which has a definite light amethyst tint. The glass identified as "Didymium" contains additional colorants, probably mainly iron, which reduces its transmittance still further. We understand that this glass was used as a sun glass by German submarine crews during World War II. It appears almost perfectly neutral in sunlight.

4. Black glasses. The black glasses, UG-6 (see Figs. 6 and 16) and RG-7 (see Figs. 5 and 16) were produced for use as infrared filters and have similar spectral transmission characteristics throughout their spectra. UG-6, as compared with the "smoky" red glass, UG-7 (see Fig. 6), illustrates what may be obtained in the nature of shift of cut-off in the red by increasing the amount of manganese and chromium within the glass. It is interesting that UG-6 (see Fig. 16) contains less B_2O_3 than UG-7 (see Fig. 18) and that the water absorption band at 2800 millimicrons is not as pronounced. It may be that the presence of a greater amount of manganese and chromium tends to decrease the water absorption. RG-7 is rendered black through the use of an excessive amount of manganese which has a single wide absorption band spreading throughout the visible spectrum (see also UG-3 in Fig. 10). Since manganese has no absorption in the infrared, beyond 1400 millimicrons this glass has the absorption spectrum of a colorless high-lead silica glass.

5. Red glasses. This group of glasses contains a large number of red glasses (see Figs. 5 and 6) having varying spectral transmissive characteristics. RG-8 and RG-10 are especially interesting in that they have essentially the same base compositions, small differences in the colorants and their states of oxidation apparently accounting for the great differences in the cut-off characteristics of the transmittance curves[3, 13]. RG-8 has the same base composition as the yellow and orange glasses GG-14 and OG-4, the cut-off simply being shifted to the red through an increase in Na_2SeO_3 and a possible different "striking" history. The sharp cut-off of these glasses (the wavelength value depending on "striking" temperature) is typical of the Cd-S-Se glasses produced in America. RG-10, containing cadmium, selenium and tellurium, but not sulfur, has a more gradually sloping cut-off characteristic since this combination of colorants absorbs more strongly in the entire red end of the visible spectrum than does the Cd-S-Se combination. However, in the infrared the absorption spectra are very similar (see Fig. 15).

RG-3 is interesting in illustrating what may be obtained through the use of Cu_2O in a high silica, high boric oxide, glass melted in a reducing atmosphere. In the visible spectrum this glass does not have the characteristic copper transmission maximum between 450 and 500 millimicrons (with copper present as CuO). Also, when copper is present as Cu_2O, it does not have the CuO transmission minimum at 800 to 900 millimicrons (see Figs. 5 and 14).

NG-1 and UG-7 (see Fig. 6) have similar transmission characteristics within the visible spectrum, both being "smoky" reds. The increased transmittance near 470 millimicrons in the case of glass NG-1 makes it essentially a smoke, or neutral glass, of very dense shade—almost a black glass. This color is produced by combining iron and cobalt oxides into the glass composition. The presence of FeO with cobalt results in a shift of the 370-380 millimicron cobalt transmission maximum to near 470 millimicrons. The FeO transmission minimum at 1100 millimicrons is accentuated by the cobalt minimum at approximately the same wavelength[1] (see Fig. 16). UG-7 is a high silica glass containing both chromium and manganese. However, except in the visible spectrum where both chromium and manganese have strong absorption bands at complementary wavelengths (see Figs. 6 and 18), the glass has a spectral transmittance corresponding to that of a colorless silicate glass. The pronounced water absorption at 2800 millimicrons is probably caused by a combination of water and B_2O_3 in the silica base glass.

The two glasses, UG-1 and UG-2, (see Figs. 9, 18 and 19), are red-purple in color resulting from the addition of cobalt and nickel oxides. Both are similar in spectral transmittance, when correction is made for the difference in thickness. The greater amount of nickel, together with a slightly lower concentration of cobalt, shifts the absorption band in UG-2 to include slightly shorter wavelengths resulting in a more "smoky" red-purple glass. In the infrared nickel produces appreciable absorption below 3400 millimicrons so that, together with the cobalt absorption bands, the glasses have a rather low infrared transmittance. These two

(*Continued on page* 354)

A RECENT TRANSLATION OF A RUSSIAN PAPER OF INTEREST TO THE GLASS INDUSTRY

Abstracts of a paper which appeared in the Russian journal of the glass and ceramic industries.

Acceleration of Melting by Novel Methods of Introducing Batch

The enormous destruction of window glass during the war and the damage done to glass plants in western and southern Russia caused numerous attempts by Russian glass technologists to accelerate the work of the surviving and the new Fourcault furnaces. A group of these attempts concerns acceleration of the glass melting process by a more rational introduction of the glass batch into the tank. The following is a review of the results obtained thereby as far as they are described by M. G. Stepanenko and I. O. Tomashevich, *Steklo i Keramika* (Glass and Ceramics) 1948, No. 1, p. 8, by K. T. Bondarev, *Steklo i Keramika* 1948, No. 3, p. 8, and by A. P. Patenko, A. A. Grachev and V. G. Gutop, *Steklo i Keramika* 1948, No. 3, p. 10.

Preheating of Batch

One of the methods is based on preheating the batch by the radiant heat from the walls of the glass tank, the surface of the molten glass etc., and by the outgoing gases. The old procedure of introducing batch into the tank is intermittent, that is large amounts are introduced rapidly but at long intervals. In the new procedure, batch enters the tank continuously. Fig. 1 shows the device used. The batch powder slides down along the inclined wall marked on the drawing 12, 13 and 14; the molten glass is shown at the bottom left of the sketch. The width of the incline (perpendicular to the plane of the drawing) is, e.g., 2 meters (6 ft. 7 in.) and the sum 12 + 13 + 14 is, e.g., 3.5 meters (11 ft. 5 in.). The tilt is different along each of the stretches 12, 13 and 14 to take care of the varying mobility of the batch during the descent.

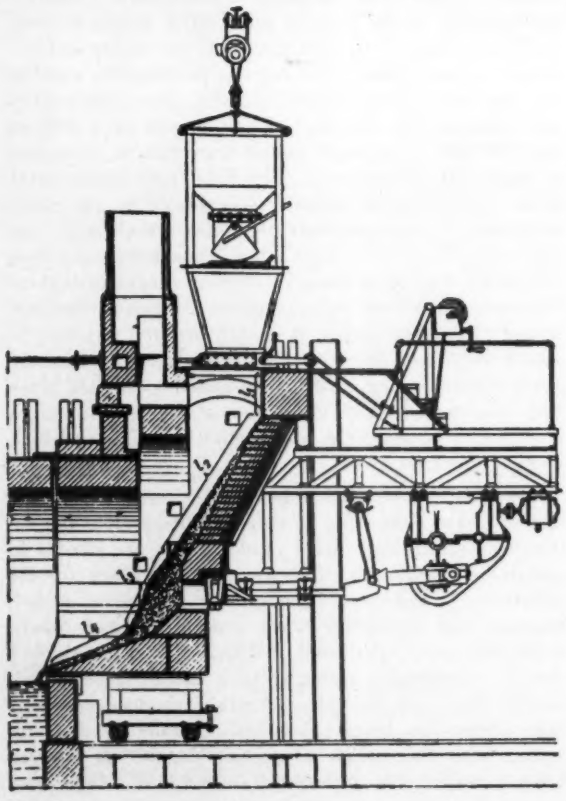


Fig. 1.

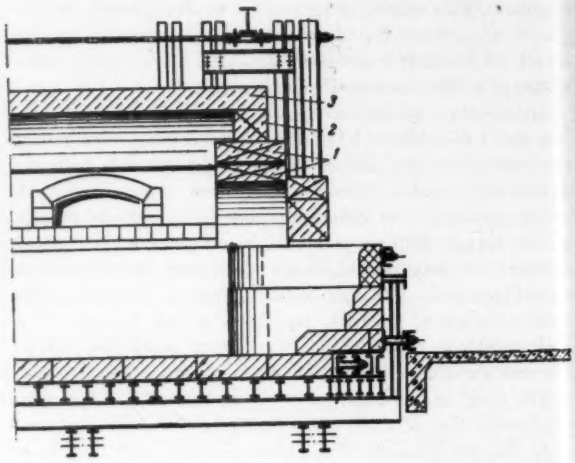


Fig. 2.

The average rate of descent is 10 m. per hour (32 ft. 10 in. per hour). The average depth of the batch on the incline is 10 cm. (4 in.). This means that an incline 2 meters wide delivers to the glass surface 2 cubic meters (70 cu. ft.) of batch per hour. The area exposed (toward the interior of the furnace) is

$$\frac{2 \text{ cubic meters}}{0.1 \text{ meter}} = 20 \text{ square meters}$$

per hour. If the volume of 2 cu.m. is added to the tank at once, the exposed area of the pile, which is partly immersed in the glass mass, is about 2 sq.m., i.e. about one-tenth of that in the new method. However, the actual ratio is even more favorable to the new procedure because the batch powder does not slide down as a solid whole.

This is caused by the temperature differences existing between the exposed surface and the deeper layers of the sliding batch. The surface temperature increases, e.g., at the following rate—

4 min.	850°C
6 min.	1000°C
8 min.	1100°C
12 min.	1200°C
16 min.	1250°C

The hot particles situated near the surface sinter and

(*Continued on page* 358)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Feeding & Forming

Hartford Forehearth. Fig. 1. Patent No. 2,467,809. This invention was assigned to Hartford-Empire Company by Madison M. Cannon and Karl E. Peiler. The invention consists of a forehearth having a series of verticle screw threaded stirrers of particular construction and arrangement. The entire object of the invention is to get the glass delivered from the outlet uniform throughout, both as to composition and temperature.

The figure shows a diagrammatic plan and section through the center of a forehearth 10 connecting a tank 14 with a delivery section 11. As shown, the orifice ring is provided with two outlets 17 and 18 for use with the "double gob" apparatus, but any other kind of device for getting the glass to the shaping instruments might equally well be used.

The stream of glass 19 first encounters a pair of stirrers 22-*r* and 22-*l* each of which has a left hand screw thread 23 submerged in the glass. It will be noted that these stirrers are not positioned in the same relation to the center line of the forehearth. Suitable means is provided for rotating these stirrers in the directions indicated by the arrows. The rotation of these stirrers in combination with the action of the screw threads gives a thorough mixing of the glass as it passes toward the feeder outlet.

The glass next encounters a pair of stirrers 122-*r* and 122-*l* which are driven in the direction of the arrows. These stirrers have right hand threads and give the glass another mixing as it advances.

A third pair of stirrers 222-*r* and 222-*l* have left hand threads and mix the glass again. The three pairs of stirrers are staggered with relation to the centerline of the forehearth.

Just before the glass enters the spout, it is again mixed by implements 71-*l* and 71-*r* but these form no part of this invention. It will be seen that the glass passes through four pairs of stirrers, three of which have screw threads thereby rendering the glass uniform throughout in every respect before it passes to the feeder outlet.

The following references are of record in the file of this patent: United States Patents: 1,414,008, Brown, Apr. 25, 1922; 1,479,511, Parsons, Jan. 1, 1924; 1,608,-710, Morrison, Nov. 30, 1926; 1,988,783, Canfield, Jan. 22, 1935; 2,061,367, Morton, Nov. 17, 1936; 2,115,408, Brosse, Apr. 26, 1938; 2,189,271, Rowe, Feb. 6, 1940; 2,196,983, Dibble et al., Apr. 16, 1940; 2,217,182, Peiler, Oct. 8, 1940; 2,230,608, Canfield, Feb. 4, 1941; and 2,238,800, Mueller, Apr. 15, 1941.

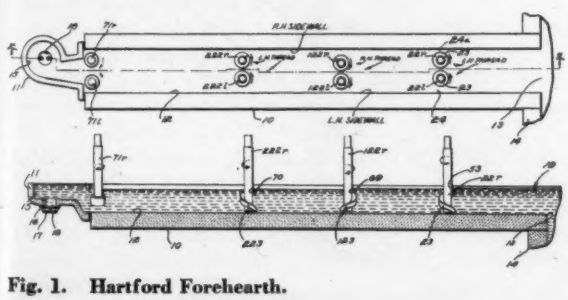


Fig. 1. Hartford Forehearth.

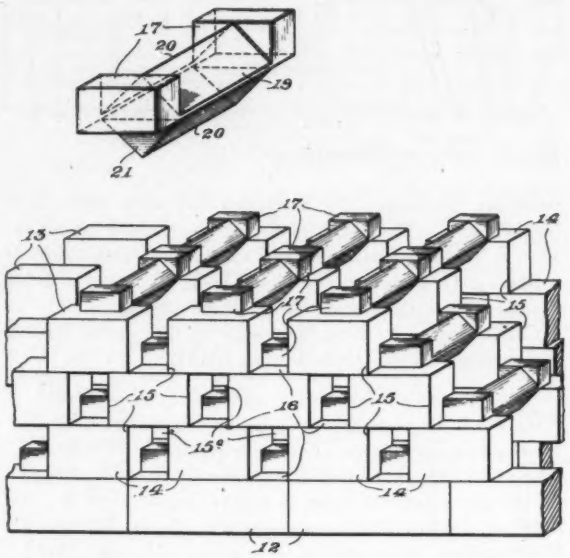


Fig. 2. Checker Work.

Furnaces

Checkerwork. Fig. 2. Patent No. 2,467,166. This checker-brick, and the checkerwork made from it, is the invention of Drew M. Thorpe of Villanova, Pa., who assigned it to General Refractories Company.

The checkerwork is built into a chamber of about the usual construction and is operated by reversing the furnace in the usual way. Rider tile 12 support partitions 13 which define the flues. Standard brick 14 rests on the tile 12 and are spaced apart so as to form staggered spaces 15, each space having a flat surface 16 which supports the end portions 17 of the new brick. Between the ends 17, the brick is polygonal in cross-section so as to provide means for easy cleaning. In a modification, transverse passages 15[a] may be left open or closed with a small brick if desired. The upper part of the figure shows one of the bricks.

The following references are of record in the file of this patent: United States Patents: 301,048, Cuthbert, June 24, 1884; 1,856,473, Drain, May 3, 1932; 1,907,-852, Miller, May 9, 1933; and 1,980,827, Reed, Nov. 13, 1934.

Glass Compositions

Rapid Melting Glass. Patent No. 2,468,868. This is a French invention made by André Danzin and Edouard Despois of Paris, who assigned it to Societe Francaise Radio-Electrique. It is noted that this patent expires December 27, 1965, instead of the usual seventeen years from the date of issue, which is May 3, 1949. This glass is intended particularly "for working into pressed glass

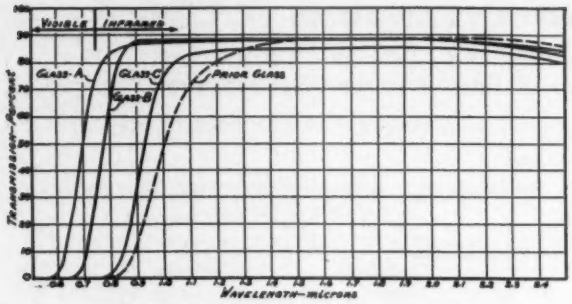


Fig. 3. Infrared Transmitting Glass.

parts in particular, by machines fed with glass in a liquid state". The glass has a low co-efficient of expansion, a low temperature of fusion, a high temperature of softening (Littleton point about 680° C.,) and a good fluidity at a little above the softening point.

Glasses coming within the range of this patent have a composition within the following limits:

	Per cent
SiO_2	34 to 38
PbO	24 to 30
B_2O_3	20 to 26
Al_2O_3	3.5 to 5.5
ZnO	8 to 9
Other matter	0 to 1

The recommended composition which has a co-efficient of expansion about like that of molybdenum is:

	Per cent
SiO_2	36
PbO	25
B_2O_3	25
Al_2O_3	5

The following reference is of record in the file of this patent: United States Patents: 2,431,983, Bastick et al., Dec. 2, 1947.

Infrared Transmitting Glass. Fig. 3. Patent No. 2,469,490. Corning Glass Works acquired this invention from William H. Armistead. The glass is opaque to visible radiations but substantially transparent to infrared radiations.

Table 1 gives examples of batch compositions coming under this patent and Table 2 the corresponding glass as calculated in per cent by weight.

Table I

	A	B	C	D	E	F	G
Sand	375	375	375	325	325	370	350
$BaCO_3$	64	64	64	160	160	...	...
$CaCO_3$	...	...	...	...	...	72	...
Na_2CO_3	128	128	128	43	43	154	171
H_3BO_3	...	...	...	26	26	...	71
$Al(OH)_3$	...	...	...	15	15	...	15
Na_2SiF_6	5	5	5	5	5	5	...
Sb_2O_3	15	12.5	10	10	10	10	10
Selenium	5	5	5	15	5	10	5
Sulfur	5	2.5	...	...	...	...	...
Carbon	5	5	5	5	5	5	5

Table II

	A	B	C	D	E	F	G
SiO_2	70.7	71.4	72.2	61.3	62.5	70.5	68.0
BaO	9.4	9.5	9.6	23.6	24.0	...	...
CaO	...	...	...	...	...	7.6	...
Na_2O	14.2	14.3	14.4	4.7	4.8	17.1	19.4
B_2O_3	...	...	...	2.8	2.9	...	7.8
Al_2O_3	...	...	...	1.9	1.9	...	1.9
Na_2SiF_6	.9	.9	.9	1.0	1.0	1.0	...
Sb_2O_3	2.9	2.5	1.9	1.9	1.9	1.9	1.9
Se	.9	.9	.9	2.8	1.0	1.9	1.0
S	.9	.5	...	...	...	...	...
Visible Color	red	dark red	black	black	black	black	black

Fig. 3 gives curves representing the per cent transmission of glasses A, B and C in a thickness of 3 mm. at various wavelengths. The dotted line, "prior glass", is shown for the purpose of comparison.

The following references are of record in the file of this patent: United States Patents: 1,271,652, Bellamy, July 9, 1918; 1,983,151, Silverman, Dec. 4, 1934; 2,049,765, Fischer, Aug. 4, 1936; 2,097,275, Fischer, Oct. 26, 1937; and 2,099,602, Fischer, Nov. 16, 1937. Foreign Patents: 44,536, France, 1934; 421,142, Great Britain, 1934; 776,979, France, 1934; 181,758, Switzerland, 1936; 445,344, Great Britain, 1936; 640,153, Germany, 1936; and 668,593, Germany, 1938. Other References: *Ceramic Industry*, Colored Glass Marbles Widely Used in Industry, page 52 (Sept. 1940).

Low Expansion Glass. Patent No. 2,469,867. André Danzin, Paris, France, assigned this invention to Societe Francaise Radio Electrique which is a French corporation.

A glass having the following composition is cited as an example of glass according to the invention. This glass readily fuses on to molybdenum and it has a Littleton point at 725° C.:

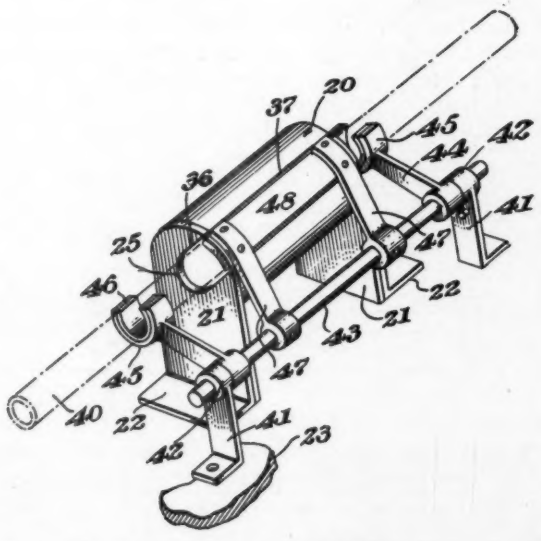


Fig. 4. Machine for Operating on Tubes.

	Per cent
SiO_2	54
Na_2O	0.7
Al_2O_3	5
MgO	1
ZnO	2.5
B_2O_3	8
PbO	12
BaO	10.3
CaO	6
As_2O_3	0.5

Claim 1 defines the invention as a special glass which has a low coefficient of expansion, a high softening temperature, equal, at least, to 600° C. and high resistance to chemical agents, which is easy to work, is particularly suited for the manufacture of vacuum tubes, more especially radio-electric tubes, and which has good electrical qualities, said glass being characterized in that it is composed of the following elements:

	Per cent
SiO_2	52 to 55
Na_2O	0.4 to 0.9
Al_2O_3	4 to 6
B_2O_3	6 to 10
ZnO	2 to 4
PbO	10 to 16
BaO	8 to 12
CaO	3 to 8
MgO	0 to 3

the total percentage of all the three ingredients PbO, BaO and CaO being equal to at least 24%.

The following reference is of record in the file of this patent: United States Patents: 2,297,453, Berger et al., Sept. 29, 1942.

Tube & Cane Machines

Machine for Operating on Tubes. Fig. 4. Patent No. 2,469,597. This is a partly automatic machine for electrically heating, sizing and forming tubes of quartz or other material. It was invented by Gustav Guigas of Livingston, N. J.

The machine includes a furnace 20 having ends 21, all being mounted on a table 23. The furnace is heated by a water-cooled high frequency coil. The ends 21 have slots 36 leading to curved openings 25. A rock shaft 43 is mounted in brackets 41 and has fixed thereon arms 44 having U-shaped sockets 45 at the outer ends to receive the quartz tube 40. The rock shaft also carries arms 47 which are attached to a door 48, the arrangements being such that the door closes the opening as the tube moves into position inside the furnace. This construction provides means for heating the tube and gives the operator full opportunity to manipulate the tube while heated.

The following references are of record in the file of this patent: United States Patents: 1,282,933, Pontius, Oct. 29, 1918; 1,724,793, Clark et al., Aug. 13, 1929; 1,749,700, Fourment, Mar. 4, 1930; 1,980,875, Northrup, Nov. 13, 1934; 2,140,213, Tegarty, Dec. 13, 1938; 2,209,739, Meyer, July 30, 1940; 2,234,863, Heetkamp, Mar. 11, 1941; and 2,393,979, Everett, Feb. 5, 1946. Foreign Patents: 339,503, Germany, July 26, 1921 and 506,384, Germany, Sept. 3, 1930.

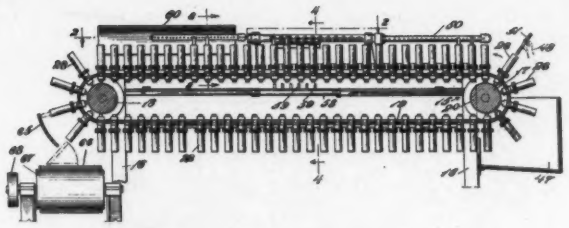


Fig. 5. Tube Bottoming Machine.

Tube Bottoming Machine. Fig. 5. Patent No. 2,469,681. George Coby of Attleboro, Mass., assigned a part interest in this invention to James V. Pugliese from Providence, R. I. By the use of this machine, the open ends of tubes or vials may be quickly and cheaply closed.

The drawing shows a frame 15 having legs 16 and supporting at the two ends pulleys 17 and 18 around which passes a belt 19. This belt is made up of a series of tube containers 28 into which the tubes are placed by the operator as indicated at 48. As the container 28 moves along, it comes into position so that burners 50 heat the projecting end of the tube. The tube is then subjected to greater heat which causes the open end of the tube to close and at about this time air pressure from a supply 58 is admitted to the inside of the tube by nozzles 59. Openings in the bottom of the carriers admit the air to the tubes. This rounds out and shapes the bottom.

The tube then passes into an annealing oven 60 after which it is allowed to cool and then dropped onto a conveyor 66. The containers 28 are rotated when necessary to give uniform distribution of heat. Various mechanisms are provided to control the travel of the tube as it is being treated.

The following references are of record in the file of this patent: United States Patents: 834,275, Dorer, Oct. 30, 1906; 854,836, Owens, May 28, 1907; 1,135,640, Watson, Apr. 13, 1915; 1,566,563, Ross, Dec. 22, 1925; 1,577,581, Knight, Mar. 23, 1926; 1,832,039, Millar, Nov. 17, 1931; 1,838,161, Soubier, Dec. 29, 1931; 1,859,011, Wales, May 17, 1932; 1,967,603, Zimber, July 24, 1934; 2,146,572, Hahn et al., Feb. 7, 1939; 2,151,191, Crane et al., Mar. 21, 1939; 2,266,417, Eisler, Dec. 16, 1941; and 2,301,940, Fries, Nov. 17, 1942. Foreign Patents: 282,057, Great Britain, Mar. 22, 1928 and 488,710, France, July 16, 1918.

Miscellaneous Processes

Anchor Hocking Stacker. Fig. 6. Patent No. 2,464,334. This stacker or lehr loader was invented by William L. McNamara and James McFee who assigned it to Anchor Hocking Glass Corporation. The original application was filed in 1942 and resulted in Patent No. 2,390,725 from which this invention was divided. The stacker is of what is known as the push bar type and it provides means for moving ware of different sizes from the cross conveyor onto the conveyor in the lehr.

The figure shows a continuously moving conveyor 1 on which the ware is deposited at the forming machine and from which it is automatically removed onto a cross conveyor 3 extending across the end of the lehr belt 6 of the lehr 5. This mechanism is not connected to the lehr or to the conveyor 1 so that it may be moved away when desired. The cross conveyor 3 may be driven in opposite directions by clutches 27 and 31 which are

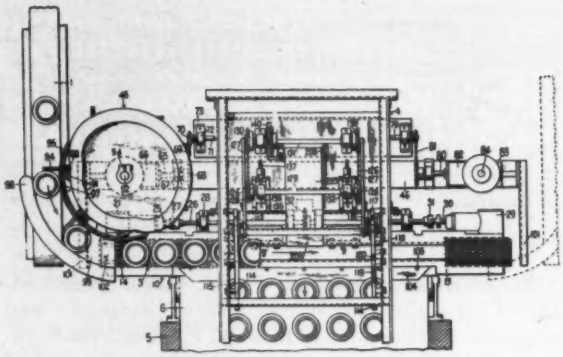


Fig. 6. Anchor Hocking Stacker.

alternately engaged or disengaged. This makes it possible for the cross conveyor to receive the ware from either end, the position at the right being shown in dotted lines. A spotter wheel 45 is shown at the left but it can be used on the other side when the ware comes in that way.

The spotter wheel carries article-engaging members 94 which are projected outwardly as the wheel rotates so as to be positioned behind each piece of the advancing ware and to push it onto the cross conveyor 3. The speed of these devices may be adjusted so as to space the ware as desired on the cross conveyor. A push bar operates periodically to push the assembled row of ware into the lehr conveyor.

The following references are of record in the file of this patent: United States Patents: 1,326,903, Augensen, Jan. 6, 1920; 1,457,364, Hallock et al., June 5, 1923; 1,850,480, Sledge et al., Mar. 22, 1932; 1,972,753, Bausman, Sept. 4, 1934; 2,113,929, Benoit, Apr. 12, 1938; and 2,362,132, Haub, Nov. 7, 1944.

Method of Sealing Ampuls. Fig. 7. Patent No. 2,464,765. This invention was assigned to F. D. Palmer, Inc., of Chicago, Ill., by Frank D. Palmer. It has long been the practice of therapeutic manufacturers to close the open mouth of an ampul after filling by manual labor. This has been a slow operation and somewhat unsatisfactory especially in that this method often left thin spots in the ampul which were liable to breakage.

At the right of the figure, the usual form of ampul as received by the packer is shown as having a side wall 12 and a bottom 13, the wall being provided with an annular groove 14 to facilitate the opening operation after sealing by scratching the glass in the groove. In this new process, the upper part of the ampul is heated at 15 by burners 16 while it is being rotated.

After the glass has been softened, the ampul is advanced to the next station where forming bars 17, press the glass inwardly to form a neck 18 while the glass adjacent is heated by burners 20. The next step is a

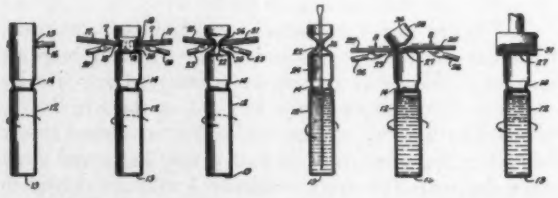


Fig. 7. Method of Sealing Ampuls.

further reduction of the original neck so as to form a narrow neck 22 by means of swagging members 21 while the heat is maintained by burners 23. The ampul is now ready for filling which is preferably done at the next station.

At the filling station, a spout 24 is introduced through the neck and the desired powder or liquid is forced into the ampul which is now ready for sealing. This is done at the next station where a pair of shears 25 has cut off the top of the ampul and closed the open end while the glass is heated by burners 26. The final step is the flattening of the sealed end by wooden pressure blocks 31 when the ampul is ready for shipment.

The following references are of record in the file of this patent: United States Patents: 596,319, Brooke, Dec. 28, 1897; 1,517,780, Goodchild, Dec. 2, 1924; 1,864,023, Ledig, June 21, 1932; 1,945,769, Brumley, Feb. 6, 1934; 1,967,603, Zimber, July 24, 1934; 2,227,757, Loepsinger, Jan. 7, 1941; 2,258,408, Cozzoli, Oct. 7, 1941; 2,265,359, De Neumann, Dec. 9, 1941; and 2,379,342, Cozzoli, June 26, 1945. Foreign Patents: 117,427, Australia, Sept. 2, 1943; 454,068, Great Britain, Sept. 23, 1936; and 654,167, Germany, Dec. 16, 1937.

Owens Jar Conveyor. Fig. 8. Patent No. 2,466,962. This conveyor and distributing device was assigned to Owens-Illinois Glass Company by Leslie G. Weymouth, Mountain View, Calif. The invention provides a device for taking jars or other ware from a single row and de-

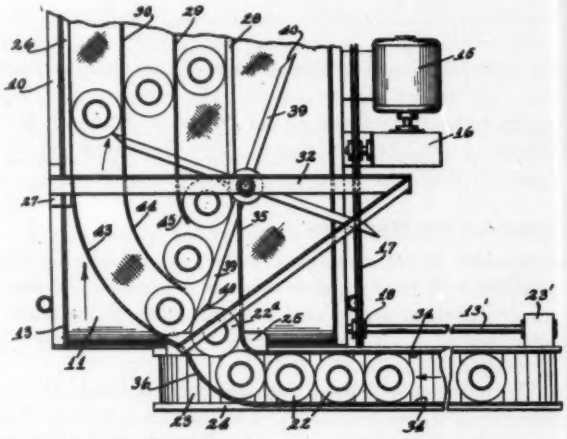


Fig. 8. Owens Jar Conveyor.

livering the jars in a plurality of rows on a conveyor of greater width and running at right angles to the first conveyor. It appears that the invention might be used to distribute ware to the conveyor of a lehr, from the cross conveyor bringing it from the forming machine, but the exact use to which the invention may be put is not mentioned.

The drawing shows a frame 10 having a roll 13 at one end and another roll at the other end (not shown) around which passes a belt conveyor 11 arranged to discharge the ware onto another belt conveyor of the same width. The conveyor 11 is driven by a motor 15 through a gear box 16 and a sprocket chain 17.

The jars 22 are brought to the belt 11 by a conveyor 23 mounted in a frame 24, the conveyor being driven by a shaft 13^1 and a gear case 23^1 connected to the motor 15. Rails 26, 28, 29 and 30 form three lanes extending over

the belt 11 and the other conveyor belt to which the jars are delivered. Additional rails can be used to form more lanes if desired. Two guide rails 34 hold the jars in line on the conveyor 23, the inner rail having an extension 25 projecting at right angles over the belt 11 and the outer rail having a curved extension 36 by which the jars are directed onto a plate 25 from which they are pushed onto the belt 11.

The jars are directed into the several lanes by a star wheel having arms 39 extending from a hub 38 which is mounted for free rotation. As shown in the figure, a jar 22[a] is in contact with an arm 39 of the star wheel which is thereby rotated in a clockwise direction pushing the three jars in front of the arm into the respective lanes by means of the curved rails 43, 44 and 45. In this way the advancing jars act to turn the star wheel which causes the three previously engaged jars to be aligned in the lanes on the conveyor 11. The single line of approaching bottles is thus re-arranged into a column of three.

The following references are of record in the file of this patent: United States Patents: 1,300,010, Porter, Apr. 8, 1919; 1,871,676, Ermold, Aug. 16, 1932; 1,894,547, Tucker, Jan. 17, 1933; 1,998,163, Meyer, Apr. 16, 1935; 2,090,129, Kimball et al., Aug. 17, 1937; and 2,363,681, McNamara et al., Nov. 28, 1944.

Method of Marking Glass. Patent No. 2,468,402. This invention was assigned to Bausch & Lomb Optical Company by Norbert J. Kreidl and Lewis P. Ohliger. The invention relates particularly to the application of marks such as trade marks to optical glass, such marks being normally invisible or nearly so but being capable of being temporarily made visible for inspection. It is apparent that similar marks might well be applied to glass other than optical.

This invention is an improvement on that shown in a co-pending application by the same inventors, filed March 17, 1945. The mark which is normally invisible, may be made visible by subjecting the article to irradiation by either short or long wave ultraviolet rays between 2000 and 4000 angstrom units.

Claim 1 of the patent describes the invention as being the method of marking glass having a polished surface comprising the steps of applying to a delimited portion of said surface a silver salt selected from the group consisting of the borate, metaphosphate, pyrophosphate, orthophosphate, vanadate, arsenate, antimonate, chromate, selenite, molybdate, tellurate and tungstate and the hydrates thereof, and heating the same to cause ions normally present in a layer of said glass adjacent said surface to be replaced by silver ions in a low and normally invisible degree of density but to a depth of penetration capable of producing a distinctly visible difference between the fluorescent appearances of the delimited and surrounding portions of said glass when subjected to ultraviolet irradiation.

The following references are of record in the file of this patent: United States Patents: 1,217,490, Northwood, Feb. 27, 1917; 1,302,353, Friedrich, Apr. 29, 1919; 1,475,473, Drescher, Nov. 27, 1923; 1,592,429, Kraus, July 13, 1926; 1,899,760, Kreidle et al., Feb. 28, 1933; 2,030,440, Fritze et al., Feb. 11, 1936; 2,056,809, Smith, Oct. 6, 1936; 2,245,783, Hyde, June 17, 1941; 2,270,307, Karnes, Jan. 20, 1942; 2,303,756, Nordberg, et al., Dec. 1, 1942; 2,333,329, Miglarese, Nov. 2, 1943; 2,340,013,

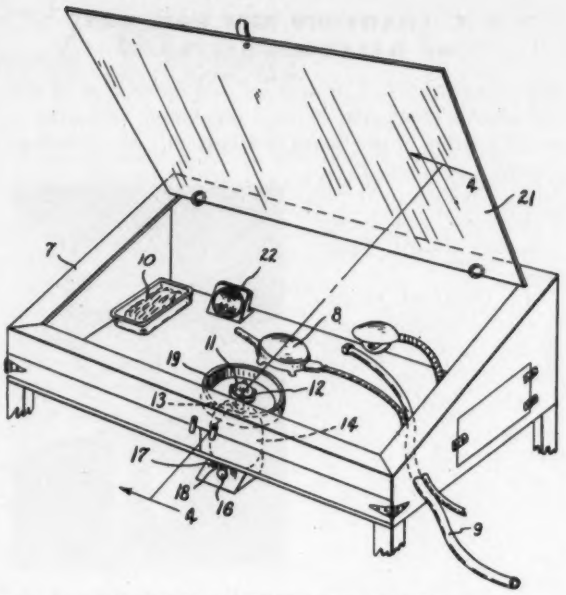


Fig. 9. Reflection Modifying Coating for Glass.

Nordberg et al., Jan. 25, 1944; and 2,355,746, Nordberg et al., Aug. 15, 1944.

Reflection Modifying Coating for Glass. Fig. 9. Patent No. 2,466,119. This invention was assigned to American Optical Company by Harold R. Moulton and Edgar D. Tillyer, all of Southbridge, Mass. This coating may be employed to reduce or increase the reflection of light, to produce light polarizing bodies and for many other purposes.

The coating is applied while the glass or other article is in an enclosure 7 which may be heated by a unit 8 or cooled by an air pipe 9. The enclosure also contains a drying agent 10 and a therometer and hygrometer 22. The article 11 to be coated is placed on a holder 12 which can be rotated by a variable speed motor. The coating solution is poured onto the article while it is rotating and a shield 19 collects the excess liquid, allowing it to escape through a drain.

This treatment is carried out by applying two coatings. The patent is highly technical and gives the results of a great many experiments. It gives full information on the method of applying the coating and the results. Those interested should make a study of the patent.

The following references are of record in the file of this patent: United States Patents: 1,809,755, King et al., June 9, 1931; 2,113,380, Nichols, Apr. 5, 1938; 2,281,474, Cartwright et al., Apr. 28 1942; 2,303,906, Benford et al., Dec. 1, 1942; 2,329,632, Marseden, Sept. 14, 1943; 2,331,716, Nadeau et al., Oct. 12, 1943; 2,347,733, Christensen, May 2, 1944; 2,356,553, Weissenberg, Aug. 22, 1944; 2,366,516 Geffeken, Jan. 2, 1945; 2,366,687, Osterberg, Jan. 2, 1945; 2,379,790, Dimmick, July 3, 1945; 2,403,685, Sachtleben, July 9, 1946; and 2,403,731, MacNeille, July 9, 1946. Other references Ser. No. 333,186, Geffcken (A. P. C.), pub. June 1, 1943.

• The appointment of Dr. Max H. Thornton as Chairman of the Chemical Research Division at Midwest Research Institute has been announced.

J. L. CRAWFORD NEW PRESIDENT OF WALSH REFRACTORIES

The election of J. L. Crawford as President of Walsh Refractories Corporation was announced following a recent meeting of the Board of Directors. Mr. Crawford succeeds retiring President Chouteau N. S. Walsh who was named Honorary Board Chairman.

Mr. Crawford became General Manager upon joining the firm in 1932. He later became Vice President and General Manager. Prior to his association with Walsh Refractories Company and following his graduation from the University of Illinois with a Ceramic Engineering degree in 1917, he was employed by the Westinghouse Lamp Company. From 1919 to 1923, Mr. Crawford served as a Fellow in the Mellon Institute where he engaged in research in the field of fire clay refractories. Following this association, he was employed with Laclede-Christy Company in a managerial and research capacity.

Other officers of the corporation are Chairman of the Board, Dr. J. C. Hostetter; Vice President and Sales Manager, R. W. Oswald; Vice President, R. D. Humphreys; Secretary, A. M. Menzi; Treasurer and Assistant Secretary, T. W. Gill.

ELECTION OF OFFICERS AT PENNSALT

The election of George B. Beitzel as President of the Pennsylvania Salt Manufacturing Company has been announced. Leonard T. Beale, President for the last twenty years, will continue with the company as Chairman of the Board.

At its annual meeting, the Board also elected William P. Drake Vice President in charge of Sales, and William F. Mitchell, Vice President in charge of Manufacturing. Mr. Drake, formerly Assistant Vice President-Sales, assumes the position left vacant when Mr. Beitzel became Executive Vice President early this year. Mr. Mitchell, previously Vice President-Manufacturing, succeeds Y. F. Hardcastle, who has retired from active participation in the company's operation but who remains as a member of the Board.

Mr. Beitzel, with Pennsalt for 19 years, and Fred C. Shanaman, President of Pennsylvania Salt Manufacturing Company of Washington, wholly-owned West Coast subsidiary, were elected to two new directorships created at a recent meeting of the Board. Mr. Shanaman also is a Vice President of the parent company.

• At the regular monthly meeting of the Board of Directors of Thatcher Glass Manufacturing Company, Inc., a dividend of 60 cents per share was declared payable on May 15, 1949 to stockholders of record May 3, 1949 on the Convertible Preference stock. This is the dividend that was payable November 15, 1948.

OWENS-ILLINOIS ELECTS NEW OFFICERS AND MAKES STAFF CHANGES

Carl R. Megowen, Vice President and Director of Owens-Illinois Glass Company, has been elected Executive Vice President of the company, according to an announcement by William E. Levis, Chairman of the Board.

Mr. Megowen entered the employ of the company in 1922 when he joined the Illinois Glass Company. In 1930 he was named assistant plant manager at the Alton, Illinois, plant and in 1932 was transferred to Toledo as comptroller. He was elected Vice President and Comptroller in 1939 and was made a Director in 1947.

Mr. Levis also announced the election of Hugh C. Laughlin, Harry J. Durholt and Raymon H. Mulford as Vice Presidents of the company. Mr. Laughlin was formerly a practicing attorney in Toledo and later became an officer of Anchor Hocking Glass Corporation, a lieutenant colonel in the U. S. Army Air Forces and, prior to joining Owens-Illinois, he was manager of the investment banking firm of Lazard Freres & Co.

Mr. Durholt joined the Libbey Glass Company, now an Owens-Illinois Division, in 1918, later becoming plant superintendent and plant manager. He became General Manager of the Libbey Division this year. Mr. Mulford joined the firm in 1933 serving at Bridgeton, N. J., Clarion, Pa., Toledo and finally on the West Coast where he was transferred in 1937 to organize the Manufacturing Control Department. He was made Plant Manager at Los Angeles in 1941, Plant Manager at Oakland in 1942 and General Factories Manager of the Owen-Illinois Pacific Coast Division in 1946. In his new assignment, Mr. Mulford will be transferred to Toledo.

DR. SCHOLES ADDRESSES A.C.S. SECTION

In an address before the Northwestern Ohio Section of the American Ceramic Society, Dr. S. R. Scholes, Associate Dean of the New York State College of Ceramics, discussed "Minor Constituents of Glass Batches".

Dr. Scholes pointed out the mechanical or chemical action within the melted batch of several of the important minor materials used in glassmaking, indicating some of the compounds formed and what properties were imparted to the finished glass product.

Among the batch agents which Dr. Scholes covered were arsenic oxide, sodium chloride, calcium fluoride, tin oxide, titanium oxide, sodium sulphate, the sulphate released from sodium sulphate, carbon, water and calcium phosphate. He also covered the coloring agents cobalt oxide and selenium and methods of decolorizing.

New officers for the Northwestern Ohio Section were also elected. They are Counselor, J. F. Chambers, National Gypsum Company; Chairman, J. C. Coleman, Kimble Glass Division of Owens-Illinois Glass Co.; Vice Chairman, K. C. Carnes, Toledo Engineering Co.; Secretary, F. C. Arrance, Electric Auto-Lite Co.; and Treasurer, H. L. Miller, Libbey-Owens-Ford Glass Company.

• B. C. Strimple, head of the industrial engineering program of Owens-Illinois Glass Company's Kimble Division spoke at the dinner meeting of the Toledo Chapter of the Material Handling Institute. Mr. Strimple's subject was "Cost Reduction Through Better Handling of Equipment".

GJ Research Digest

Chemical Durability, Specular Gloss and Transmittance of Optical Glasses

Although the most effective non-reflecting surfaces are obtained by deposition of films of chosen index of refraction and controlled thickness, less effective but useful films can be produced by leaching the silicate glasses with numerous aqueous solutions. This fact has been known since 1892 when it was observed that old, tarnished photographic lenses sometimes gave more satisfactory performance than new lenses of the same aperture.

As the three properties of glass—durability, non-reflecting films and increased transmittance—seem to be so intimately associated, they have been compared in an investigation by Hubbard and Rynders (National Bureau of Standards, Research Paper R.P. 1933, November 1948) over an extended pH range for three types of optical glasses and chemical Pyrex.

The three optical glasses chosen were a borosilicate crown, a barium crown and a flint. The attack experiments were made by the interferometer method because it offered a rapid and convenient means of studying the relative rates of solution of the glasses over a wide pH range.

Rectangular specimens (Pulfrich slabs 19 by 30 by 5mm, pitch polished on one face and optically flat to within one-half fringe) were partially immersed in the desired buffer solutions, the surfaces of which were covered with a thin layer of liquid petrolatum to prevent evaporation during the period of the test. Specimens of each glass were exposed for 6 hr at 80°±0.2°C to Britton-Robinson universal buffer solutions covering a pH range from 1.8 to 11.9. This range was extended to pH 0.65 by means of a sodium acetatehydrochloric acid buffer. All exposures were made simultaneously.

The extent of the attack was determined by observing the displacement of the interference fringes when the exposed specimens were placed under a fused-silica flat. Observations were made with a Pulfrich viewing apparatus by using unfiltered helium light for illumination.

The change in appearance of the glasses caused by the various treatments was evaluated by observing the percentage of specular gloss retained by the exposed area for 45° incident beam compared with the unexposed portion of the specimen. The measurements were made by means of the Hunter Gloss Meter, by using an adapting shield for supporting the small specimens.

The transmittance of the treated and untreated areas was determined after the specimens had been reground on the unpolished surface with superfine emery to insure that this area was uniform and contributed no uncertainty to the measurements. Thus the change in transmittance resulting from attacks is attributable to one surface. To obtain information concerning the effect on appearance of the surface brought about by increased attack in the alkaline range, the three optical glasses were exposed to 5 percent of NaOH solution at 80°C for different periods of time, ranging from 15 min to 4 hr.

The data so obtained were plotted to show attack, gloss retained and change of transmittance after six hours exposure at 80°C. over the pH range 0.65 to pH 11.9. The borosilicate optical glass showed detectable attack in the acid range with an appreciable increase between pH 5 and pH 9, followed by a more pronounced increase as the alkalinity increased beyond pH 9. At no pH did the chemical durability of this glass compare favorably with that for Pyrex. It was interesting to note that Pyrex demonstrated little or no change in appearance (gloss retained) or transmittance for the entire pH range except for the high alkalinities above pH 11, where the attack became increasingly vigorous. The borosilicate optical glass, in contrast, showed a large decrease in gloss in the pH region of optimum durability of the glass with only a slight change in specular gloss for the region of pronounced attack. However, the transmittance of the specimens showed an appreciable improvement in the pH range of maximum durability and a decrease in the pH range of increasing attack. Essentially these same features are shown in a somewhat exaggerated and confused fashion by the data obtained on the other two optical glasses.

In general, the durability of the three optical glasses is best in the acid range below pH 5. In such solutions, there is a preferential dissolving of alkali and other metal ions leaving behind a silica-rich surface layer of index refraction considerably lower than the index of the base glass.

These silica-rich layers are of uncontrolled thickness and furnish reflection-reducing films that lower the specular gloss of the surface and improve the transmittance. However, these films are not of the correct index of refraction, $i_{film}=\sqrt{i_{glass}}$, nor are they adjusted to the optimum thickness, $t_{film}=\frac{1}{4}\ \lambda$, for the maximum improvement of transmittance or reduction of surface reflection. In the alkaline range the silica layer is dissolved, thus preventing the formation of a reflection-reducing film with the attendant improvement in transmittance. Within this range where silica-rich layers are no longer formed, interference colors do not appear.

Obviously, the amount of stain developed by an exposed sample of glass cannot be used as a reliable measure of the amount of attack. However, useful and interesting information can be obtained from these stains if the specimens have been exposed to a solution in which certain constituents of the glass are preferentially dissolved.

The attack on these optical glasses by the buffer solutions for the range pH 5 to pH 8 is accompanied by a reduction in transmittance. The more pronounced attack in the alkaline solutions above pH 9 does not seriously affect the percentage of transmittance of glasses BSC 517 and BaC 572 until the highest pH is reached.

From this set of comparisons it is easy to understand how so much confusion might arise in choosing an adequate serviceability test for optical glasses. However, the data are interesting in that they show at a glance the best pH region for leaching to produce reflection-reducing surfaces and increased transmittance, with the accompanying improved performance of optical elements.

The data on gloss retained and the general tarnished appearance of the surface after exposure in acid solutions could easily be used superficially and wrongly to condemn the optical glasses. It is evident that this test alone does not differentiate a desirable reflection-reducing film from a pitted, etched or otherwise damaged surface. The transmittance data are necessary to establish this distinction.

As a result of this investigation, it was concluded that the specimens used in the interferometer procedure for determining the chemical durability of glass lend themselves readily to a quantitative evaluation of the change in appearance (gloss retained) and the transmittance of the glass brought about by controlled exposures to solutions. The results obtained present an over-all picture of some desirable as well as undesirable characteristics of the optical glasses studied. The data reemphasized the difficulty of using any one of the three properties, chemical durability, gloss retained or change in transmittance after exposure, alone as an indicator of serviceability. In fact, in the absence of additional information, such as long-time atmospheric-exposure test or hygroscopicity of the glass, it is doubtful that these three properties either singly or combined are a reliable indicator of the ability of optical glasses to maintain clear polished surfaces in service.

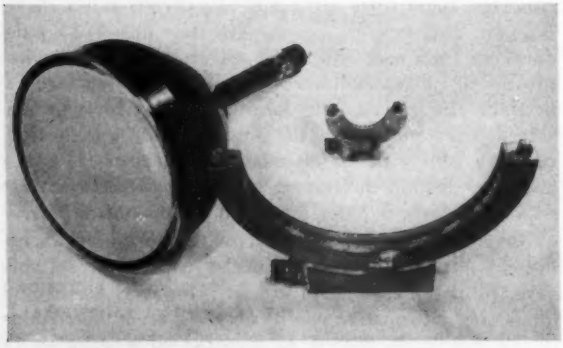
Effect of Rinsing on Chemical Durability of a Container Glass

That the chemical durability of a glass surface can be improved by treating it when hot with certain vapors is well known. It is also known that there is a difference in absorption on a glass surface of different ions from solutions and that certain ions tend to improve the chemical durability resistance when present in the glass or when present in the exaction solution.

K. C. Lyon reports in the February 1949 issue of *The Journal of the American Ceramic Society* the results of an investigation, the purpose of which was to determine if major improvements in the chemical durability of a soda-dolomite-lime bottle glass could be accomplished by rinsing the glass with a dilute solution of a common inorganic salt.

New, run-of-the-lehr, four and eight ounce capacity, standard prescription shape bottles were used as samples. The bottles were treated by placing about 50 ml. of the desired rinsing material (containing the inorganic salt) in each, rolling three or four times by hand to get complete wetting of the inner surface after which they were emptied, drained and inverted for about five minutes. All bottles were rinsed three times with doubly distilled water (specific conductivity less than 2.0 micromhos) before being subjected to the one hour at 121°C. autoclave test procedure.

From the results obtained, it was concluded that the precision of the results did not justify a detailed conclusion as to the action of any specific solution with respect to any other, many of the treatments being no more effective than a water rinse. Of the various ions used, copper seemed to have the most pronounced effect, a fact which may be of importance in those operations in which glass is used in or following contact with copper solutions.



TELEVISION TUBE FABRICATION SPEEDED BY NEW WELDING HEAD

The "Kinescope", or viewing tube, used in conjunction with television tube fabrication, may be either hand-blown or fabricated by welding together pressed parts. Welded Kinescopes of the common 10-inch and 12½-inch size are assembled from three sections: neckpiece, funnel and faceplate. The faceplate and funnels are pressed on semi-automatic glass-pressing machines from a leaded glass. The neckpiece is either blown and the pieces cracked off, or made from tubing, one end of which is flared. Two welds are required in each Kinescope, one to join the neckpiece to the funnel, and the other to join the funnel and the faceplate.

The neckpiece-to-funnel weld is being made using a special welding head developed by The Linde Air Products Company, a unit of Union Carbide and Carbon Corporation. Heads for the neckpiece-to-funnel weld and for the funnel-to-faceplate weld are illustrated above.

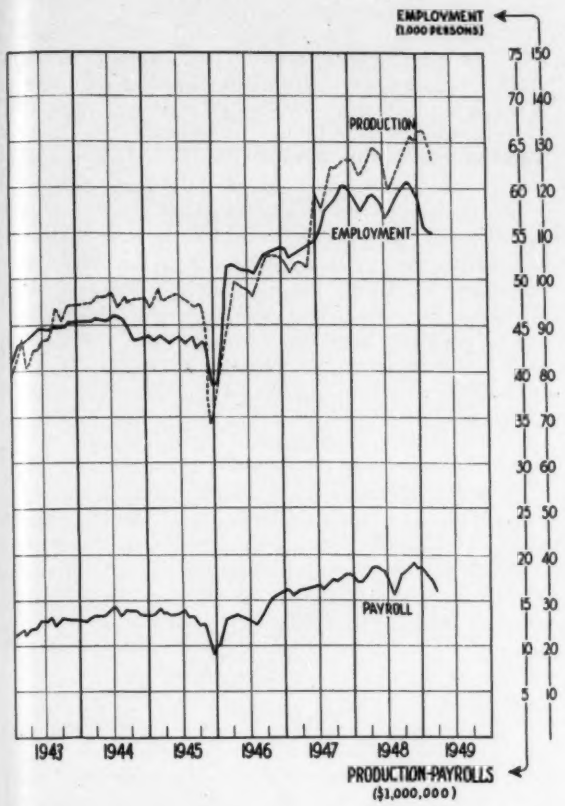
The earlier burners used oxygen and natural gas in a post-mixed flame, which was very broad and of low velocity. The difficulty encountered was that this type of flame heated a broad band in the weld area and required a long time for the molten glass to harden before the welded section could be handled.

The new Linde head, utilizing premixed gases and of special design, has eliminated these objections, according to the company's report. Also, the problem of excessive breakage has been corrected. The Linde head incorporates a time-delay control valve so that oxygen flows to the head first and is turned off last. This prevents backfiring that might otherwise occur, due to the high oxy-fuel gas ratio used. This high oxy-fuel gas ratio is required to prevent reduction of lead oxide in the glass, which would result in an objectionable black stain. Because a high oxy-fuel gas ratio is used, a new flame tip of special design was developed for this process.

After making the neckpiece-to-funnel weld, this assembly is then welded to the faceplate on another lathe, using a Linde welding head of proper size. The finished weld is flame-annealed at a separate station. The assembly is then placed in an annealing lehr. Finally, the ware is checked and packaged for shipment to tube manufacturers.

CURRENT STATISTICAL POSITION OF GLASS

GI THE GLASS INDUSTRY'S INDEX



March 1949 activity in the glass industry, according to the Production Index, decreased 4½ per cent from the previous month's estimated $66,000,000, to reach $63,000,000. During March 1948 activity had been reported to be an approximate $65,000,000, or 3 per cent above March this year. Total estimated production in the glass industry at the close of the first quarter of 1949 has reached $196,000,000, as compared with $188,400,000 at the close of the same period in 1948. This represents an increase of 4 per cent for this year over last year.

Employment and payrolls: Employment in the glass industry during the month of March 1949 was 109,400. This is 1½ per cent below the February employment figure of 111,200. During March 1948, employment was 117,800, or 7 per cent above March this year.

Payrolls continued to drop and for the month of March 1949 were estimated to be $17,000,000. During the previous month they had been estimated at $18,000,000. This represents a decrease of more than 4 per cent from the February figure. During March 1948, payrolls were an estimated $18,500,000, or 8 per cent above March 1949. Total estimated payrolls for the January-March 1949 period were $53,350,000. During the corresponding period in 1948, glass manufacturers had paid out an estimated total of $53,500,000—a difference of only $150,000.

Glass container production, based on figures released by the Bureau of Census, indicated little change for the month of April 1949 as compared with the previous month. Production during April reached 7,035,075 gross, as compared with the March figure of 7,224,371 gross—a difference of 2½ per cent. Production during April 1948 was 8,978,389 gross, or 21½ per cent above April 1949. Total glass container production thus far in 1949 has reached 28,150,757 gross, as compared with 33,220,964 gross produced during the same period in 1948. This represents a difference of 15 per cent.

Shipments of glass containers for the month of April 1949 dropped slightly from the 7,093,106 gross reported

GLASS CONTAINER SHIPMENTS
(All figures in Gross)

	April 1949
Narrow Neck Containers	
Foods	649,229
Medicinal & Health Supplies	925,999
Chemicals, Household & Industrial	491,792
Beverages, Returnable	532,958
Beverages, Non-returnable	5,498
Beer, Returnable	211,188
Beer, Non-returnable	268,332
Liquors	588,806
Wines	251,786
Toiletries & Cosmetics	351,411
Sub-total (Narrow)	4,276,999
Wide Mouth Containers	
Foods	1,644,326
Dairy Products	251,308
Home Canning	147,742
Medicinal & Health Supplies	226,829
Chemicals, Household & Industrial	95,366
Toiletries & Cosmetics	108,079
Packers' Tumblers	118,334
Sub-total (Wide)	2,591,984
Total Domestic	6,868,983
Export Shipments	181,594
Total Shipments	7,050,577

GLASS CONTAINER PRODUCTION AND INVENTORY
(All figures in Gross)

		Production April 1949	Stocks April 1949
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	2,491,729	3,395,347
	Wide Mouth	2,235,595	2,462,411
Dairy Products		250,478	247,693
Home Canning		*74,489	953,463
Beverages, Returnable		570,456	738,391
Beverages, Non-returnable		5,514	6,187
Beer, Returnable		183,597	745,186
Beer, Non-returnable		227,888	371,344
Liquors		615,482	467,093
Wines		256,815	278,828
Packers' Tumblers		123,032	115,391
Total		7,035,075	9,763,334

Specify!

ISCO

Potassium Carbonate, Hydrated 83-85%

ISCO DIAMOND I BRAND

Potassium Carbonate, Calcined 99/100%

(BAGS & BARRELS)

Sodium Silicofluoride
Beeswax
Ammonium Carbonate
Iron Chloride

INNIS, SPEIDEN & CO.

117 LIBERTY STREET
NEW YORK 6, N. Y.

BOSTON · CINCINNATI · GLOVERSVILLE
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E. S. BROWNING CO., INC.
SAN FRANCISCO · LOS ANGELES

for March to reach 7,050,577 gross—a difference of 42,529 gross. Glass container shipments during April 1948 were 7,811,641 gross, or 9 per cent above April 1949. Total glass container shipments at the close of the January-April 1949 period were 26,772,818 gross. This is about 18 per cent below the 32,953,598 gross shipped during the corresponding period in 1948.

Stocks on hand at the close of April 1949 were 9,763,334 gross, as compared with 9,760,208 gross at the close of March and 7,866,639 gross on hand at the close of April 1948.

Automatic tumbler production showed a decrease of a little more than 3 per cent for the month of April 1949. The figure reported is 4,638,566 dozens as compared with the previous month's 4,796,462 dozens. Production during April 1948 was 5,422,749 dozens. Shipments for April 1949 were 4,922,749 dozens which is about 2 per cent below the 5,038,318 dozens shipped during March. Shipments during April 1948 were 5,628,215 dozens. Stocks on hand at the close of April were 8,270,234 dozens; at the close of March, 8,473,669 dozens; and at the close of April 1948, 8,510,267 dozens.

Table, kitchen and household: Manufacturers' sales of machine-made table, kitchen and household glassware dropped close to 7½ per cent for April 1949 to reach a total of 3,375,007 dozens. During March, sales were 3,645,428 dozens. During the month of April 1948, sales were 3,713,799 dozens. At the close of the 12-month period ending April 1948, total manufacturers' sales were 40,003,640 dozens as compared with 42,638,683 dozens sold during the corresponding period ending April 1948.

The figures for automatic tumbler production and sales of table, kitchen and household glassware of one manufacturer are estimated due to its inability to meet THE GLASS INDUSTRY's deadline. However, the totals for this concern have been estimated in order to complete the compilation of total industry figures. These total figures will be adjusted in the next issue of THE GLASS INDUSTRY.

OWENS-CORNING APPOINTMENTS

Harold Boeschenstein, President of Owens-Corning Fiberglas Corporation, has announced the appointment of L. R. Kessler as Vice President of the corporation and General Manager of the Pacific Coast Division, and Ben S. Wright as Vice President of the corporation and General Sales Manager. W. C. Winterhalter was also named Vice President and Sales Manager of the Pacific Coast Division.

Mr. Kessler, associated with Owens-Illinois Glass Company from 1932 to 1946, joined the Fiberglas Corporation three years ago when he was placed in charge of preliminary development work on the West Coast. He was named General Manager of the Pacific Coast Division when it was established in 1948.

Mr. Wright joined the corporation in 1940 and was assigned to the general office sales organization as Manager of the Fiberglas Yarns Division. In 1945, he became Manager of the Cleveland branch office. He returned to Toledo in 1947 when he was made General Sales Manager.

NEWLY COMPLETED BOTTLE PLANT

● Depicted are views of one of our latest installations recently erected and operating abroad. This plant can produce upwards of 100,000 bottles every 24 hours when making 12 oz. weights. The range of sizes is flexible to meet local demands . . . from 1/2 ounce to one gallon, either narrow neck or wide mouth.

Our services are specialized in the construction of modern and complete glass plants embodying the most advanced engineering design, automatic methods, and machinery, for the manufacture of bottles, jars, and similar containers, window glass and tableware items, to suit local conditions in foreign countries.

Glass factory installations supplied by us are operating successfully in many countries of the world.

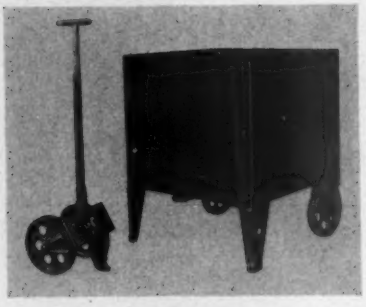
We offer complete installations or partial equipment for **Bottle Plants • Window Glass Plants • Tableware Plants • Oil Fired or Gas Fired Tank Furnaces • Automatic Forming Machines and Presses • Automatic Feeders • Annealing and Decorating Lehrs • Searing-Off Machines • Decorating Machines.**

GENERAL GLASS EQUIPMENT COMPANY

Atlantic County Trust Building

ATLANTIC CITY • NEW JERSEY

NEW EQUIPMENT AND SUPPLIES



NEW SCRAP TRUCK

Factory Service Company, 4633 North 21st Street, Milwaukee 9, Wisconsin, has announced a new scrap truck specially designed to work with and increase the usefulness of the revolving head fork lift truck.

The new unit consists of a bin-like superstructure made of heavy steel plate panels securely welded to a flat steel deck transport. Fabricated steel channels, built to accommodate the forks of standard fork lift trucks, extend from front to rear panels just above the transport deck. Being of welded and riveted construction throughout, there is not a bolt, nut or screw to work loose.

A revolving head fork truck can pick up the unit from either front or back, take it to the next machine or move it directly to the scrap pile, baling machine or railroad car for dumping. With the fork trucks engaged in the channels, the scrap truck can be turned to any desired angle, or completely upside down while dumping, yet remain entirely secure.

NEW "DURO-GLO" GLASS COLORS

The Vitro Manufacturing Company, Corliss Station, Pittsburgh 4, Pa., has announced the development of new, superior alkali-resistant glass colors for screen application on glass containers.

These new colors, named "Duro-Glo," offer many advantages. Of particular note is their lower maturity, greater stability and longer firing range. Exhaustive tests under actual production conditions have shown "Duro-Glo" colors have a maturing range of approximately 200° F. Because of this unusually long firing range, "Duro-Glo" colors are not affected by normal lehr fluctuations. They may be safely applied and fired at any temperatures from 1000° F. to 1250° F. without blistering of color, deformation of the glass or chain marks. The result is an extremely stable color with high gloss and opacity.

EVEREADY BRIKSAW

Eveready Briksaw Company, 1509 South Michigan Avenue, Chicago 5, Illinois, has announced its new Eveready Briksaw which features both wet and dry cutting, instant portability and streamlined design with rugged construction. The pump used for wet cutting cannot be damaged by operating it for dry cutting. In four sections, the cutting head height can be adjusted for such widely different size materials as brick, quarry tile, etc.

Another feature is the patented "Toe-Matic" control by which the operator with a light upward tilt of the foot treadle resets the cutting head at any desired angle, then presses down to cut. Among the cutting speeds possible are firebrick cut in four seconds; glass block, eight seconds; face brick, eight seconds; vitreous brick tile, twenty-one seconds, etc. A complete line of Eveready Bricksaw blades is available in dry abrasive, wet abrasive and diamond blades.

HIGH-SPEED DIAMOND DRILLS

Starlite Industries, Inc., 58th at Market Street, Philadelphia 39, Pa., has developed high speed diamond drills as a result of some recent research development which demonstrated drilling speeds with diamond instruments that indicate opportunity to cut manufacturing costs far below conventional drilling methods for glass, ceramics and abrasives.

In a series of drill tests on ¼" plate glass, the new diamond drill reduced time required for the operation to a new low of only 10 seconds. The results were found to be exceptionally clean, with a minimum of chipping.

The Starlite core drills feature an equal weight of diamonds fused in a radically new metal bond. The newly developed bond is tough enough to reduce core wall thickness to only .021". As a result, the thin wall improvement increased speed in drilling because less material is involved in the cutting operation.

MULTI-SWITCH CAPACITROL

Wheelco Instruments Company, 847 W. Harrison Street, Chicago 7, Illinois, has developed a new type of indicating controller called the "Multi-Switch."

The new instrument will become a part of the company's Capacitrol line of controllers for the measurement and control of process variables such as temperature, voltage, amperage, pressure, speed, etc. Incorporating such features as a distant view scale, front accessibility, plug-in chassis design and voltage selector plug, the "Multi-Switch" Capacitrol is available with a maximum of four switches to provide a selection of six different switching sequences for a large variety of control functions.

A high resistance, fully compensated, direct reading meter movement with Alnico V Magnet is used for applications which fall in the pyrometric range. Models using resistance thermometer measuring systems are available for low temperature operation.

CATALOGUES RECEIVED

North American Manufacturing Co., 4455 East 71st Street, Cleveland 5, Ohio, has issued Bulletin 58, "Certified Combustion by North American."

The pamphlet illustrates an installation of a battery of certified combustion gas burners and describes and illustrates the Series 58 Gas Burner. Several line drawings show single burner, two burner and multiple burner arrangements for manual, automatic and zone controls.

The Magnesia Insulation Manufacturers Association, 1317 F Street, N.W., Washington 4, D. C., is publishing a 96-page manual on 85% Magnesia insulation, illustrated with line drawings and photographs.

Among the subjects covered are properties of 85% Magnesia, determination of correct thicknesses, application and finishing procedures and insulation maintenance. The appendix contains a discussion of practical applications of heat transmission theory, definitions of technical terms, fifteen tables of data on 85% Magnesia and related subjects, a glossary of trade terms and a list of trade names of the insulating material and accessories.

The Cambridge Wire Cloth Company, Cambridge, Maryland, is now offering a new, revised edition of their popular woven wire cloth catalog.

This new catalog is complete with specifications, descriptions and illustrations of meshes, weaves, metals and alloys included in the diverse line of industrial wire cloths and screens. The new 85-page book contains additional information which makes it a valuable reference work for anyone concerned with filtering and bulk handling of materials.

It is profusely illustrated with photographs of Cambridge's facilities and typical examples and applications of its wire filter cloths, screens and special fabrications.

Of special interest and value is a section devoted to metallurgical data on nearly every major metal and alloy —information which has been gathered through Cambridge's many years of experience in manufacturing woven wire conveyor belts, filter screens and specialized wire fabrications.

Pittsburgh Corning Corporation, 307 Fourth Avenue, Pittsburgh 22, Pa., has issued a brochure containing informative data, plus technical specifications, photographs and many charts and diagrams to introduce cellular glass insulation, PC Foamglas, to the residential field.

NOW—from Vitro . . .

OFFERING

- ✓ ***Lower maturity—1000° F.***
- ✓ ***Longer firing range—approximately 200° F.***
- ✓ ***Greater stability***

than any colors ever developed for screen application on glass containers!

The completely new and amazing "Duro-Glo" Glass Colors provide the answer to your requirements for superior ware with the ultimate in eye appeal and a minimum of rejects.

Exhaustive tests under actual production conditions have proved "Duro-Glo" the finest colors ever developed for squeegee application on commercial glasses. Because of their unusually long maturing range of approximately 200° F., these newly-developed glass colors are not affected by normal lehr temperature fluctuations. They may be safely applied and fired at both the low and high temperature limits without blistering of color, deformation of glass or chain marks. The result is an extremely stable color with a high gloss and opacity never before provided by colors of this type.

For complete details on the new, sensational "Duro-Glo" Glass Colors, contact a Vitro representative today, or write direct!

PUT VITRO'S NEW, EXPANDED FACILITIES TO WORK FOR YOU!

The combination of techniques and background gained in over 41 years' experience in color manufacture plus the most modern laboratory and research facilities, new production equipment and a new, unique reference sample system are offered to the trade with complete confidence. Our representatives and technicians are always at your service.

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CERAMIC COLOR SPECIALISTS FOR OVER 41 YEARS

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SOME CURRENT METHODS OF GLASS DECORATING . . .

(*Continued from page* 325)

Roman Gold or burnished gold is pure gold powder fluxed to fire at glass decorating temperatures. Subsequent to firing, the decoration is burnished with round grain sand and water or with a glass fiber rubbing brush in order to smooth down the surface and develop the true character of the metal.

Bright Gold Squeegee Paste is also made in a heavy oil consistency for silk screen printing. Silk screen stencils made of #25 silk (approximately 200 mesh) are used.

Lusters. A number of metallic resin compounds known as lusters are used to produce various transparent color effects such as ruby, mother of pearl, orange, pink, amethyst, green, etc. Some pre-war colors can not now be reproduced due to uranium being no longer available. The lusters are restricted primarily to purely decorative applications since they lack the durability of vitreous enamel.

Luster colors may be applied with a flat lustering brush or by spraying. Spraying is not often resorted to, however, owing to the rather costly nature of the lusters since whatever is lost in the over-spray cannot be reclaimed.

Lusters are extremely sensitive to any contamination from foreign matter such as dust, lint, etc. and for that reason, the atmosphere of the decorating department should be dust free. Small particles of dust falling on the luster creates a point of surface tension difference so that the surface film will show pock marks of no color or else as a speck with a light halo surrounding it. It goes without saying, of course, that if the glass surface is not perfectly clean, it should be washed.

Interesting soft decorating effects can be achieved by rubbing various colors into previously sand blasted areas as is being done by the operator in the above picture.

Ruby luster develops a beautiful depth of color if the ware is given two applications and two firings.

Amber Stains. The only true glass stain for direct use is an infusible preparation containing silver chloride which may be applied to the glass by spraying, dipping or painting. During the firing-in period, a penetration of the glass by silver ions produces a permanent transparent amber color. The average firing range for amber stains is in the neighborhood of 1000°F. Also it is interesting to note that firing an amber stain application for 24 hours, say at 800°F, will often produce a color possibly as intense or even more so than could be obtained if the same were fired at 1000°F for 30 minutes.

This lathe-like arrangement facilitates the rapid lining or banding of tumblers with either liquid bright gold or color.

Copper Ruby Stain. Another glass stain indirectly achieved is the copper ruby. Here again, the stain owes its color and permanence to an ion exchange. The glass surface is brought into contact with different copper compounds which react with the glass at high temperatures with replacement of alkali by copper, the copper ions migrating into the glass and replacing the alkali ions which in turn migrate out of the glass. Subsequent to contact with the copper compound, the glass is submitted to reduction at temperatures between 1000 and 1100°F.

Surface contact of the glass with the copper compound is usually brought about by 1) exposing the glass at high temperatures to copper halide vapors* or, 2) dipping in a bath of a molten copper salt‡ or 3) by screen printing, painting or spraying of a copper salt and subsequent heating to approximately 1100°F.

The permanence of this stain makes it very desirable for use on chemical laboratory ware and infra-red heat lamps. Production tedium, however, has apparently been a very limiting factor as far as general use is concerned.

Decalcomania. No discussion on glass decorating processes would be complete without some reference to the use of decalcomania. Printed in several colors, precisely registered with line and shading work not possible by any other decorating means, the decal has much to offer. Recently revived interest has stimulated new development work which, it is hoped, will broaden their field of use and improve behavior under presently employed firing conditions.

There are two general types of decals, those printed by the well known lithograph press on Duplex Paper and the screen printed decals which may be either on Duplex Paper or on the Simplex slide-off type of decal paper. Neither are in wide use as a glass decorating means, although it may be said that the litho decal is the backbone of dinnerware decorating by the potteries. But, for glass, their use has been curtailed by such limiting factors as short firing cycle and rather rapid rate of temperature rise of the decorating lehr, and, for flint

(*Continued on page* 352)

* U.S. Patent 2,075,446
‡ U.S. Patent 2,430,520

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SOME CURRENT METHODS OF GLASS DECORATING . . .
(*Continued from page* 350)

glass, the transparency of the decoration. For this last and very important reason, litho decals are at their best only when applied to opal glass.

The heavy litho varnish used in the off-set method of printing plus the varnish placed on the ware at the time of transfer are dissipated with difficulty when heated, and if not entirely removed prior to initial fusion of the color, blistering, discoloration and crizzling may and most likely will result.

Screen printed, slide off decals, on the other hand, due to a heavier deposit of color, are more opaque and possess greater color strength than litho decals. For that reason, they can be used on either flint or opal glass. Although now in use to a very limited extent, increased development work since the war indicates that decal manufacturers are hopeful of stimulating broader commercial acceptance. Reduction in unit costs and more efficient labor saving means of transfer are likewise under study.

Lamp Bulbs. Within the past several years, there has been a growing production of electric lamp bulbs with fired on coatings. White is the dominant enamel used. It has the very definite characteristic of greater light diffusion. As a matter of fact, the entire glass envelope seems to glow with equal intensity whereas in the frosted bulb, the light source is identified by a hot spot surrounding the filament area. With white enamel coated bulbs, light efficiency is rarely reduced more than 3% by the fired on coating.

The enamels used are both of the lead and leadless types. Lead base enamels are far more weather resistant, although the leadless enamel presents no problem of reduction and darkening at the burn off line.

The bulb envelopes may be coated (1) by dipping in an alcohol suspension of the enamel or (2) flooding from above onto the bulb through a fine mesh wire screen.

Conclusions

It cannot be denied that fused on enamels have become a dominant factor in glass sales. We are now entering once more on a buyers market. To meet the whims of a more cautious buying public, judicious use of color can be depended upon to pep up lagging sales.

Acknowledgments

We wish to acknowledge our grateful appreciation for the courteous cooperation extended by the following companies in permitting us to make most of the photographs used in illustrating this paper: The Beaumont Company, Brockway Glass Company, Buck Glass Company, Dominion Glass Company, Limited, W. S. George Pottery Company, Glenshaw Glass Company, Washington Company.

DR. SILVERMAN SPEAKS ON GLASS

Dr. Alexander Silverman, head of the Department of Chemistry at the University of Pittsburgh, delivered an illustrated lecture on "What's New in Glass" before the St. Joseph Valley Section of the American Chemical Society.

Cleaner Glass, Low Maintenance
with **CRYSTALITE Forehearths**

REMMEY CRYSTALITE (mullite-bonded mullite) is produced in all shapes necessary to make up the forehearth assembly. Burner blocks, cover blocks, channels, spouts, tubes, plungers and orifice rings are built to meet specified requirements. These CRYSTALITE parts mean better, more efficient production by offering:

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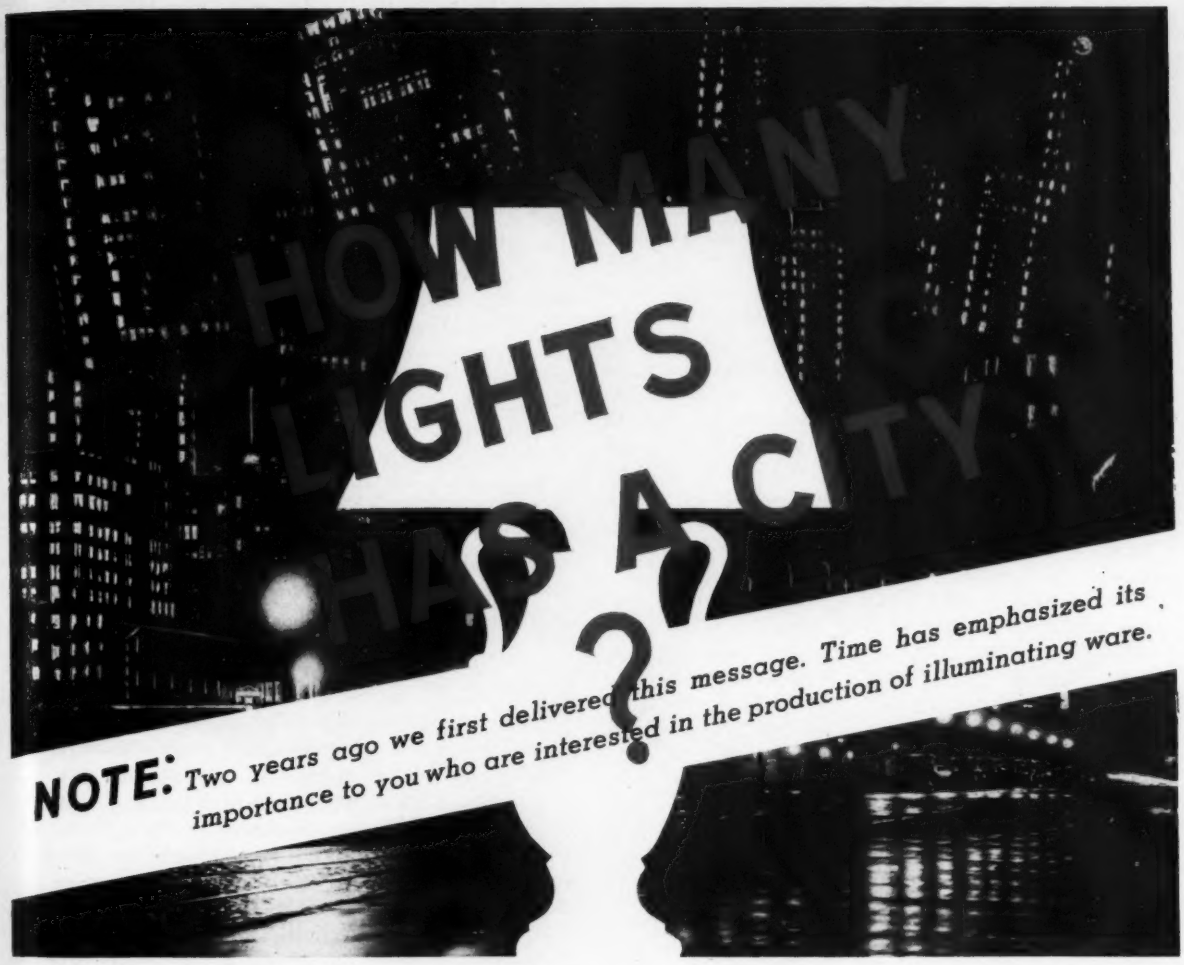

NOTE: *Two years ago we first delivered this message. Time has emphasized its importance to you who are interested in the production of illuminating ware.*

Whatever the statisticians answer, it is definitely true that many lights in many cities will gleam more richly and more invitingly tonight because they are made with illuminating glass colors by Pemco. Over the whole wide range of lighting—from the reproduction of a tiny candle light to the most modern of fluorescent lighting of today—Pemco technicians are aiding in the task of bringing greater lighting beauty and lighting durability into homes and businesses. One of the more pleasant things of life is good lighting—and Pemco Glass Colors are superior for illuminating ware. That is why Pemco is a good name to know and to be remembered. You are further assured that you will find Pemco Glass Colors meeting the resistant requirements of the particular application for which they are intended.

A request on your business letterhead will bring you samples—quickly!

PEMCO CORPORATION

BALTIMORE PEMCO MARYLAND

COLOR DIVISION

(*Continued from page* 335)

glasses, as well as UG-3, were produced for use as ultraviolet filters and are not essentially different from available American glasses.

6. Yellow and orange glasses. The four glasses of this group, GG-5 (see Figs. 6 and 17), GG-11 (see Figs. 6 and 25), GG-14 (see Figs. 6 and 13), and OG-4 (see Figs. 5 and 19), are similar in general transmission characteristics. Other than absorption in the ultraviolet and visible spectrum, cadmium and sulfur have no appreciable effect upon the transmittance. As the amounts of cadmium and sulfur are increased (see the curve for GG-11 as compared with GG-5) the cut-off wavelength is simply shifted toward the red. The addition of selenium in place of sulfur (see curve of GG-14 as compared to GG-11) apparently changes the general transmission characteristics but little except that, as the amount is increased, the cut-off is shifted to longer wavelengths (see curve for OG-4) as in the case of an increase of the cadmium sulfide in a cadmium sulfide sulfur glass. The value of the cut-off wavelength has been found, at this Bureau as well as in other laboratories, to be even more dependent upon the "striking" history than upon the composition. All of these glasses are available in American counterparts.

7. Green glasses. The six glasses of this group (see Figs. 7, 8, 17, 21, 22 and 23) range in color from a light blue green (BG-9 and BG-16) to a yellow green (GG-16). VG-3 is a vivid yellow green phosphate glass containing uranium as a colorant. The transmittance curve shows the effect of both uranium and phosphorus. The minima at 430, 480, 540, 660, 1100, 1500 and 2300 millimicrons all seem to be caused by the uranium oxide. The absorption band at 2800 millimicrons is caused by water and the rapidly decreasing transmittance at longer wavelengths by phosphorus. Phosphorus probably accentuates the water absorption band also.

VG-4 is a borosilicate crown glass having almost the same color as VG-3, but a markedly different absorption spectrum caused by copper and chromium oxides. The chromium transmission maximum at 550 millimicrons is evident, but the chromium oxide has masked the normal copper maximum between 450 and 500 millimicrons. The water absorption at 2800 millimicrons is probably accentuated by the large amount of B_2O_3 in the glass (approximately 10 per cent).

BG-9 and GB-16 are approximately the same light blue-green color and have similar absorption spectra throughout the ultraviolet, visible and infrared. They have the same base composition and differ only in the amount of FeO added. BG-16 is darker in shade as would be expected for the increased iron content. Both were melted in a reducing atmosphere. These glasses show the effect of iron as FeO on the spectral transmittance. The short wavelength ultraviolet is effectively absorbed and the red and near infrared regions of the spectrum are attenuated, while the near ultraviolet and blue end of the visible spectrum are affected but little. A number of similar glasses have been produced in this country[5].

VG-11 is a vivid green glass as would be expected from the shape of its transmittance curve (see Fig. 7). The color results from a combination of the colorants —copper, chromium and the didymium oxides—and the absorption spectrum is similar to that for VG-4 except for increased absorption in the region of 700 to 1200 millimicrons due to a considerable increase in copper and a slight increase in chromium content modified by the presence of lanthanum and the didymium oxides.

GG-16 is an interesting glass, "smoky" yellow green in color, similar in spectral transmittance to Lovibond 35-yellow glasses[11] or certain eye-protective glasses[5, 12]. The transmittance curve has a maximum at 560 and a minimum at 660 millimicrons. The infrared transmittance is that of a colorless silicate glass. This glass is probably of a zinc crown base with iron oxide (Fe_3O_4) and uranium oxide as colorants.

8. Blue glasses. In this group are four glasses, BG-1 and BG-2 (see Figs. 10, 11, 24 and 25) colored by cobalt only, and BG-12 and BG-28 colored by both cobalt and copper. BG-2 contains more cobalt and boric oxide than BG-1, the former causing stronger absorption in the visible and both increasing the absorption in the infrared spectrum. The characteristic maxima at 370 and at approximately 800 millimicrons are present as are the minima at 570 to 675 and at 1400 millimicrons. For wavelengths above 2400 millimicrons, the addition of cobalt results in a general decrease in the transmittance.

BG-12 and BG-28 (see Figs. 11, 21 and 26) are copper-cobalt glasses having identical base compositions. BG-12 has a transmission maximum at 390 to 400 millimicrons. This maximum has been shifted from the characteristic cobalt position at 370-380 millimicrons by the presence of the copper oxide. The cobalt maximum at 800 millimicrons is practically wiped out by the copper. In the case of BG-28 an increase in the CuO content together with a decrease in the cobalt, shifts the cobalt maximum from 370-380 millimicrons to about 460 millimicrons. The decreased cobalt content in BG-28 in comparison to BG-12 appears to be more effective in increasing the transmittance in the infrared than is the increased copper content in decreasing its value (see Figs. 21 and 26).

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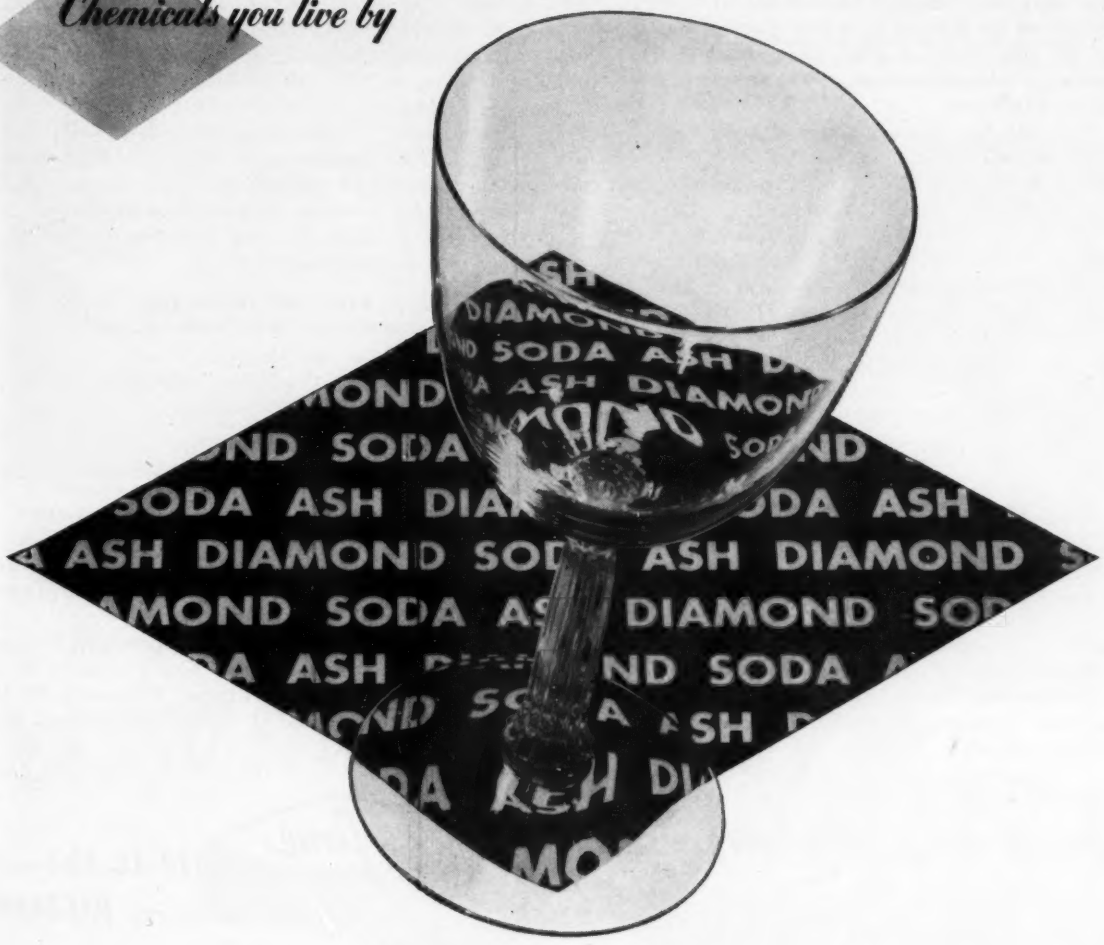

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G-E OPENS NEW GLASS TUBING PLANT

The Lamp Department of General Electric Company has announced the opening of a new plant at Logan, Ohio, for the production of glass tubing used in the manufacture of incandescent lamps. The factory cost approximately $2,000,000.

Plans call for the manufacture of small-diameter glass parts for incandescent lamps and it is expected that eventually the factory will produce tubes for regular and slimline fluorescent lamps.

Built by the H. K. Ferguson Company, the plant consists of a one-story factory building having approximately 210,000 square feet of floor space. It is situated on a 15-acre site north of Logan. The building houses two glass melting furnaces constructed by the Frazier-Simplex Company.

Manager of the new glass works is B. G. Greenman, Jr., who joined the firm in 1937 after being graduated from Iowa State College with a B.S. degree in industrial science.

NEW FIBERGLAS PIPE WRAP

A new, high-strength fiberglas wrap for underground pipe lines has been announced by Owens-Corning Fiberglas Corporation. Known as coromat, the wrap is of glass fibers reinforced with long, continuous strands of glass yarns.

By incorporating the yarns in a multi-directional pattern in the mat, the tear strength of the basic pipe wrap has been increased 200 to 400 per cent, according to company officials.

GLASS FIRMS AND UNION AGREE ON NEW CONTRACT

Agreement on a new contract for 18,000 workers in ten plants of the Libbey-Owens-Ford Glass Company and Pittsburgh Plate Glass Company was reached, according to a report by a union official. It was further reported that the wage question was left open.

The question of wage increases was left open pending the outcome of steel and auto workers contract negotiations. Management granted increased vacation allowances, a wider provision in arbitration agreements and named July 4, Labor Day and Christmas as paid holidays, it was further reported.

ELECTION OF OFFICERS AT AMERICAN WINDOW GLASS

The stockholders of the American Window Glass Company re-elected J. H. Clark, J. A. Haberkorn and G. P. Rhodes to the Board of Directors at its recent annual meeting.

At the organization meeting of the new Board, H. H. Parker, formerly Director of Sales, was elected to the newly created position of Vice President in Charge of Sales. K. S. Wilson, formerly Assistant Director of Sales, was appointed Director of Sales to succeed Mr. Parker. H. W. McIntosh was appointed to the newly created position of Manager, Technical Departments.

Other officers re-elected by the Board were A. S. Crandon, President; Danial Maggin, Vice President; R. J. Whalen, Secretary; J. L. Williams, Treasurer; D. M. Veon, Jr., Controller; and D. F. Wilson, Assistant Secretary and Treasurer.

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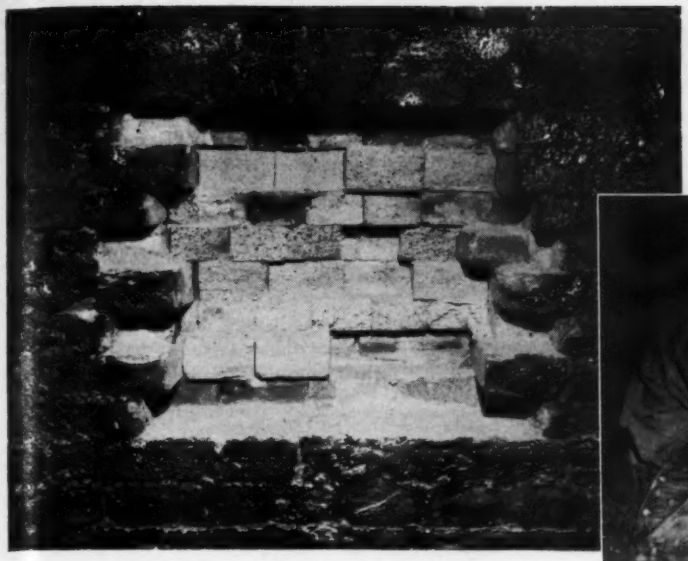

Section of a furnace wall, with damaged brick removed, ready for repair.

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A uniform, moldable mixture of high grade refractory materials, H-W Plastic Fire Brick provides an easy, practical means of repairing furnace walls, and of making burner blocks, arches, door linings and special shapes. Monolithic linings also can be readily made of H-W Plastic Fire Brick, with ordinary tools and without special experience. Comes in 3-inch slabs, ready to use, Standard and Super grades.

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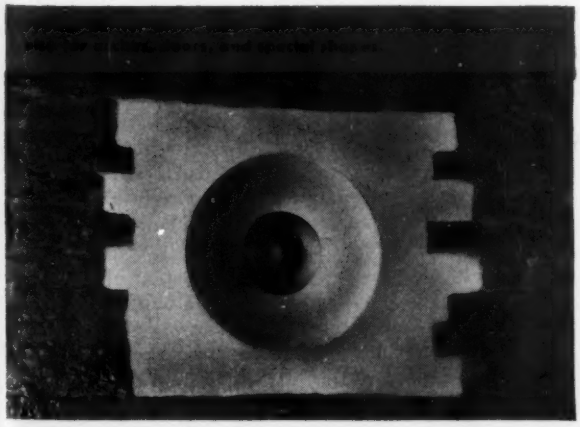

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(Continued from page 336)

coalesce to bigger lumps, over 1 cm. (about ½ in.) in diameter, which roll down quickly and expose the cooler layers underneath. In this manner, the surface exposed to hot radiations and hot gases is increased and the heating-through of the batch is accelerated.

The rate given above, that is 2 cu.m. or about 1 metric ton of batch per hour is observed when the maximum temperature of the melting end is 1370-1390°C and the batch contains sodium sulfate as the only source of sodium. The batch on the incline is heated a) by exhaust gases and b) by radiation.

About 10 per cent of the exhaust gases passes over the batch, the rest being driven in the usual manner to the regenerator. These 10 per cent of the gases are originally at 1350°C. Their temperature drops to about 350°C after the passage over the batch. The amount of heat left in the batch is about 900000 cal. per hour in a furnace consuming 2 cubic meters of batch per hour. If the same volume of gas would have gone to regenerator, its temperature at the exit would be 450°C and only 800000 cal. per hour would be left behind. Since the coefficient of utilization of regenerators, on the average, is 65 per cent, only 520000 cal. per hour would return to the furnace. Hence, the incline saves about 380000 cal. per hour. This is about 4 per cent of the heat input.

The amount of heat absorbed by the batch from the radiation is about 4 to 6 times as great as that given off by the exhaust gases. Because of the lower temperature of the batch, the flow of heat from the flame space toward the batch is more rapid than toward the glass surface. The heat supplied to the usual glass tank is utilized

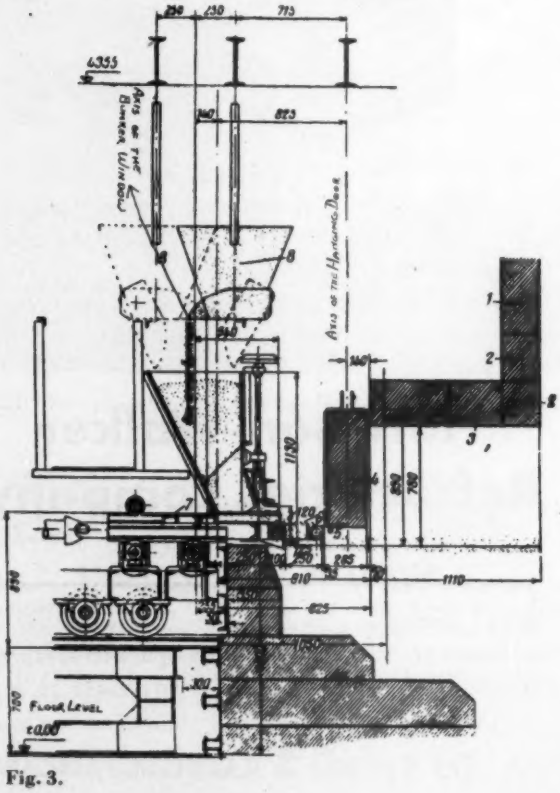

Fig. 3.

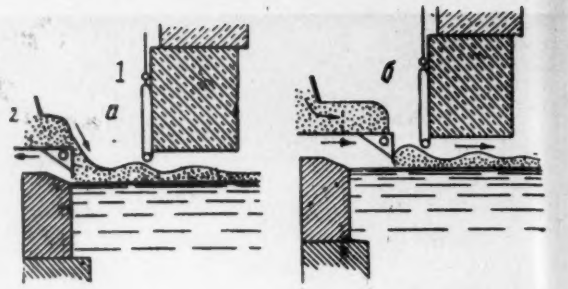

Fig. 4.

to about 18 per cent, but that part of it (about 19 per cent) which is supplied to the incline seems to be utilized to 88 per cent. All in all, the saving of fuel (peat) in actual production was 10-12 per cent.

Thin-layer Feeding

The other method uses spreading of batch in a thin layer over the surface of molten glass. Fig. 2 shows the "thin-layer feeder" in position. Fig. 3 helps in understanding the mode of action of the feeder. All measures in Fig. 3 are in mm.

1 is an outside wall of the furnace (which is to the right of the drawing). In this wall a wide (500 cm., about 16 ft. 5 in.) window is made, the roof of which consists of a special double arc (*2,2*). The arc *3* protrudes from the wall. The window is nearly closed by the hanging door *4* the bottom of which is about 2 cm. (or 1 in.) above the level of glass (the horizontal line without any number). The door is of metal lined with refractory brick. The outside edge of its bottom is protected by a cooler *5* consisting of a ½ in. pipe.

The feeder proper is a horizontal table which rolls alternately toward and from the window. When it is as near the window as possible, its front is marked by figure *6*. It can be rolled away from the window along a stretch of 250 mm., marked on the drawing. The batch falls from the container *8* and the funnel onto the table, covering it as far as the ridge *7*, when the table is near the window. (The figure *7* on the drawing shows the position of the ridge when the table is far from the window). When the table rolls back, the batch rolls from it onto the glass surface in a thin layer. The table is provided with a cooled vertical front plate of sheet iron, which almost touches the glass surface. When the table rolls forward again (i.e. toward the window), this front plate pushes the batch along the glass surface further in the interior of the tank.

Fig. 4 illustrates these operations schematically. In it *1* is the hanging door and *2* is the table. In Fig. 4a the table moves backward (i.e. from the window) and deposits batch on the glass surface; and in 4b it moves forward and the iron plate pushes the batch inside.

The table makes 2 to 2.5 complete oscillations per minute, and the iron plate pushes the batch layer by 20-25 mm. (8-10 in.) per minute. The batch covers the glass surface for about 3.5 meters (11 ft. 5 in.).

The yield of glass before the installation of the thin-layer feeder was about 540 kg. per sq. m. of the melting part per day when the usual (in Russia) sulfate batch was used, or 650 to 700 kg. per sq. m. when calcium fluoride was added. After this installation the yield was 900 to 1000 kg. per sq. m.

THE GLASS DIVISION AT CINCINNATI . . .

(*Continued from page* 330)

Engineers, through its research staff, undertook to review and evaluate the data on this subject. The lack of much needed information led to the formulation of a comprehensive research program which has been in progress since early 1945. This program includes the determination of heat flow characteristics of single sheets of flat glass and two sheets in various combinations, of glass block on several sizes and patterns and of several types of rolled or configurated glass. A study of the effect of shading devices is also contemplated. The final step is the translation of experimental and analytical information into practical tables of design data which must be suitable for any location in the country and extensive enough to cover any common application.

The apparatus and methods used in this research was described in detail and some of the test results which have been obtained were presented. The significance of the results lies in the facts that:

1) Heat flow data have been obtained under actual weather conditions, out-of-doors with laboratory control of the indoor environment; 2) Data have been obtained for glass which have not heretofore been available; 3) The solar transmittance studies show the importance of energy distribution and angle of incident rays; and 4) The problem of heat flow due to absorbed solar energy and temperature difference is a complex one and requires additional study and analysis of the boundary conditions that regulate heat flow to or from the surroundings.

The Effect of a Tank Design Change on Glass Flow. *By F. L. Bishop, American Window Glass Co., Arnold, Pa.*

I—Method of Measurement. The method used in this investigation is the one reported in a previous paper.[1] Briefly, cerium hydrate is added to the batch fill for about one hour and its appearance in the finished glass detected by the increase in light absorption at 325 millimicrons. Samples of glass are drawn from the tank at various times and places and examined under "black light" for fluorescence. The amount of cerium hydrate used was the equivalent of 0.007% ceric oxide in the contents of the tank.

II—The Changes Made in the Tank. The major changes made may be seen in Figure 1 which shows the outline of the tank and center line profiles before and after the change. The old method of filling by piles was replaced by a Frazier-Simplex blanket feed. The narrow neck between melting and refining zones was replaced by a shadow wall. Finally the melting and refining sections were reduced in depth from five to four feet.

III—The Effect on the Glass Flow. The changes were all in the direction of simple flow. Going from the batch toward the machines, we have first the method of feeding. The blanket feed gives a smoother, more uniform fill. With batch piles moving down the tank at different speeds and in different directions, the cerium is added in spurts as different piles melt out. The blanket feed gives a more uniform line of batch being converted into glass.

The narrow neck gave a high velocity to the glass in the center of the stream and probably provided some return currents from its relatively cold walls. The shadow wall apparently has very little such effect.

The change in the depth made the greatest difference. Peyches[2] gives an excellent discussion of currents in a tank. He states "The speed of the superficial current is proportional to the difference of the temperature in the two compartments and to the cube of the depth of the bath". The cube of the present depth (4 feet) is 64 and of the old depth (5 feet) is 125, a ratio of practically ½. As calculated from the first incidence of cerium in the machines, the average overall speed since the change is 17 feet/hour and before the change, it was 35 feet/hour.

Figure 2 shows deviation-time curves on one machine before and after the change. The difference in time of arrival of the first effect and the extreme variability before the change are very evident. Figure 3 shows the same thing for a machine closer to the main tank. The extreme peaks characteristic of the near machines previously are nearly gone after the change.

IV—Results on the New Tank. Because of these extreme peaks and the general irregularities of results on the old design, it is difficult to show several features which come out clearly in the remodelled tank. Figure 4 compares results on three machines after the changes had been made. Points plotted on this graph are averages of samples taken over an entire eight hour shift. The curve covers twelve days results. The best smooth curve has been drawn through the points. These represent machines at three different distances from the main tank. Besides the difference in time of arrival, a great difference is seen in the scattering of the points. This scattering is closely connected to the distortion quality obtainable on these machines.

The symbol, ID1, shows the periods during which the machine is not operating. The results after such down times confirm the result previously noted by Preston[3] and others that the circulation in the working end is unaffected by the presence or absence of "pull".

These curves integrated over all the machines on the tank give the curves of Figure 5. The curves of Figure 5 may be interpreted as showing, for any given time, the percentage of the cerium added which has already been drawn in finished glass. For example, at the end of one day on the old tank, 9% of the cerium added had been drawn while on the new tank, only a little over 1% had appeared.

If we take curves for individual machines such as shown in Figures 2 and 3 and smooth them by averaging over each three hour period, we obtain the result shown in Figure 6. This shows a distinct periodic cycling which I have interpreted as a recirculation path in the main tank.

V—Conclusions. The method used is a powerful tool to determine the flow of the glass in a tank. The results expected from the design change made are generally confirmed by the test results. Particularly the dependance of speed of flow on the cube of the depth is confirmed. The variability of certain machines explains the relatively poorer results obtained.

Confirmation was also found for the fact that the best quality, from the standpoint of homogeniety, is obtained on those machines having the quickest, most simple, flow path.

Viscosity and Density of Molten Optical Glasses. *By L. Shartsis and S. Spinner, National Bureau of Standards, Washington, D. C.*

The viscosities and densities of a number of optical glasses representing all types produced at the National Bureau of Standards were measured with a counterbalanced sphere method. In this method the relative velocity of a platinum sphere suspended in the molten glass from one arm of an analytical balance is measured by observing the motion of the balance pointer through a Brinell microscope.

When weights, placed in the weight pan, were selected to give a range of velocities of the sphere in both the up and down directions it was found the load vs velocity curve was a straight line. The slope of the line when the ball was ascending was generally greater than when the ball was descending. This effect is probably caused by the liquid clinging to the supporting wire. By extrapolating the load velocity line back to zero velocity, the effective weight of the sphere in the test liquid was obtained and from this and the appropriate constants of the ball, the density of the liquid could be calculated.

Preliminary studies of the method were made with a highly viscous liquid whose velocity was measured with a freely falling sphere apparatus. Corrections for wall effect were made by using the Faxen equation. Determinations of the average slope of the load velocity lines over a range of viscosities from 50 to 30,000 poises revealed that $\eta \neq K S$, where S is the average slope and K is an instrument constant. The value of K increased with viscosity. It is probable that this behavior is at least partially accounted for by the friction and inertia of the balance. Although the slope is not directly

1. F. L. Bishop, "Tracing Flow in Glass Tank Furnaces," Journal American Ceramic Society 28 (11), 308-10-1945.
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3. F. W. Preston, "The Behavior and Misbehavior of Glass in Tanks," Bulletin American Ceramic Society 15 (12), 409-433, December 1936.

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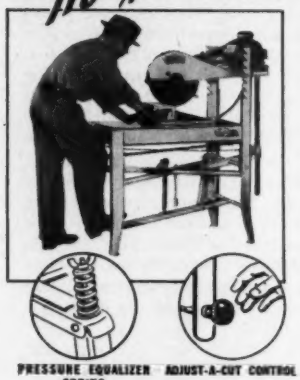

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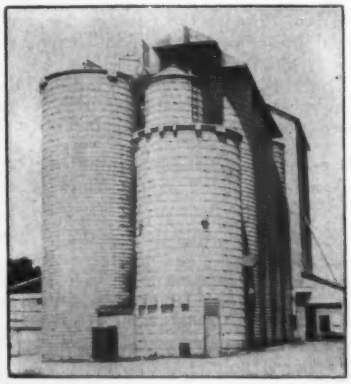

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proportional to the viscosity, it has been found empirically that the logarithm of the slope is linear with the logarithm of the vicoscity. [6]

The densities obtained with the sphere method agreed well in the temperature range 1000-1200°C with those obtained by measuring the volume of a given weight of glass contained in a platinum volumetric flask. Expansivities calculated from the density results obtained with the sphere method in the temperature range 1000-1200°C indicate that the expansivity in this range is from 2 to 3.5 times that in the solid range (100-400°C). The Optical Flints have low expansivities of the order of 20×10^{-6} microns /cm/°C whereas the Barium and Borosilicate Crowns go up as high as 36×10^{-6}.

The viscosity data has not been completely analyzed as yet. Qualitatively the Flints have relatively low temperature coefficients of viscosity whereas the Barium Crowns have high ones. Comparison of results obtained with the sphere method and a rotation viscometer has shown good agreement. The sphere apparatus is simple, rugged and has stood up well with continued use.

HARTFORD-EMPIRE ACQUIRES HENRY & WRIGHT COMPANY

The announcement of the purchase of Henry & Wright Manufacturing Company by the Hartford-Empire Company in a move to broaden its field of operations has been announced. The new subsidiary, purchased at a cost of $1,200,000, showed total current assets of about $870,000 in excess of current liabilities as of February 28, 1949.

Since its organization in 1934, Henry & Wright has shown a profit every year. In 1948, net earnings after taxes amounted to approximately $266,000. The Henry & Wright plant contains about 50,000 square feet of office and manufacturing floor space, fully equipped with modern machine tools, most of which were acquired during the past war at values considerably below current replacement.

The new subsidiary has been engaged in the development and manufacture of automatic machinery, as is Hartford-Empire and its Standard-Knapp Division. They have a line of high-speed dicing machines ranging from 25 to 150-ton capacity for the forming and blanking of various types of parts. They also have developed many other automatic machines and their customers include the largest and best-known industrial concerns in the nation.

Frank K. Simmons, who has been President of Henry & Wright Manufacturing Company, is retiring for reasons of health. Sixten F. Wollmar, President of the parent company, has been elected new President of the subsidiary. All other personnel will remain the same.

WALSH REFRACTORIES TO OCCUPY NEW OFFICES

Walsh Refractories Corporation announces the occupancy on or about June 1 of its new general offices at 101 Ferry Street, St. Louis 7, Missouri.

Modern throughout, the general office has been designed to insure overall improvement in the handling of administrative detail. The plant is strategically located adjacent to the company's St. Louis plant which is expected to more effectively coordinate activities of office and factory and expedite service to the customer.

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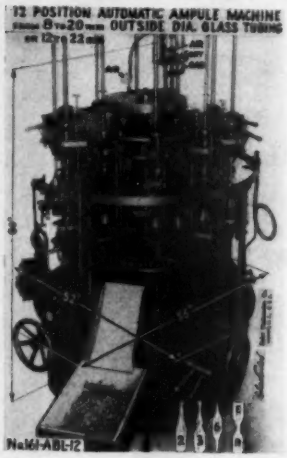

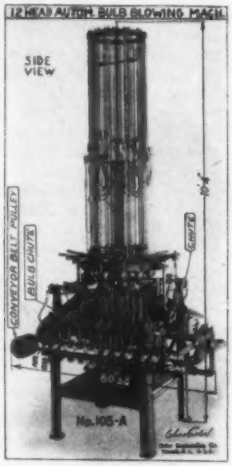

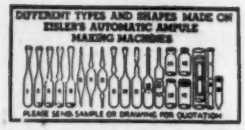

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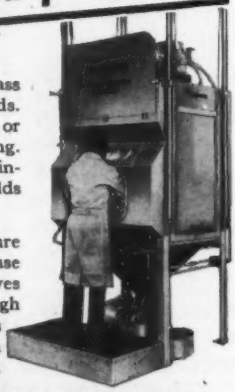

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(*Continued from page* 319)

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4. Von G. Tammann and H. Elsener von Gronow, "The Cutting of Plate Glass," *Z. Anorg. Allg. Chem. 201*, 37-40 (1931).
5. C. Gurney, "Delayed Fractures in Glass," *Proc. Phys. Soc.* (London) *59*, 169-85 (1947).
6. W. B. Hardy, *Phil. Mag. 38*, 49 (1919).

WAVEGUIDE WINDOWS FOR MICROWAVE SYSTEMS

Glass waveguide windows scientifically designed to permit silver soldering without damage to micro-waveguide systems operating at frequencies ranging from 3,000 to 40,000 megacycles have been announced by the Electronics Division of Sylvania Electric Products, Inc.

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Elimination of bending stress in the window glasses is the result of applied research work done by Messrs. Martin, Pease and Robert of the company's Electronics Division at Boston, in which glass and kovar have been combined through the use of special sealing techniques.

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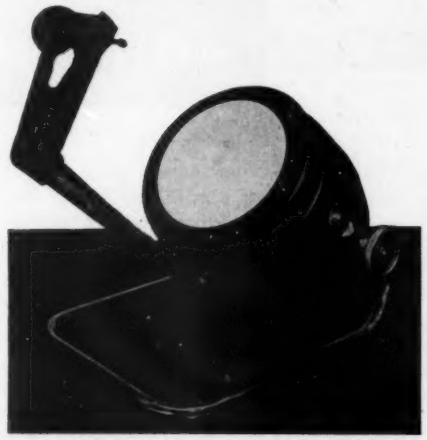

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AMERICAN POTASH & CHEMICAL ANNUAL REPORT

In the Annual Report of the American Potash & Chemical Corporation, it was shown that total production of chemicals was 641,068 tons, compared with 594,764 in 1947. Sales amounted to $14,520,964 compared with $13,637,700 during the previous year. Net income was $1,727,154 as against $2,106,319 in 1947 and $1,514,105 in 1946.

Earnings on the Class A and Class B stocks were equivalent to $2.74 after payment of a full year's preferred dividends. Earnings were $3.60 a share in 1947 and $2.87 in 1946.

Net working capital decreased from $10,461,629 as of December 31, 1947 to $3,443,831 as of December 31, 1948. During the same period fixed assets increased by $7,138,515. Quarterly dividends totalling $1.50 a share were declared and paid during the year on the Class A and Class B stocks.

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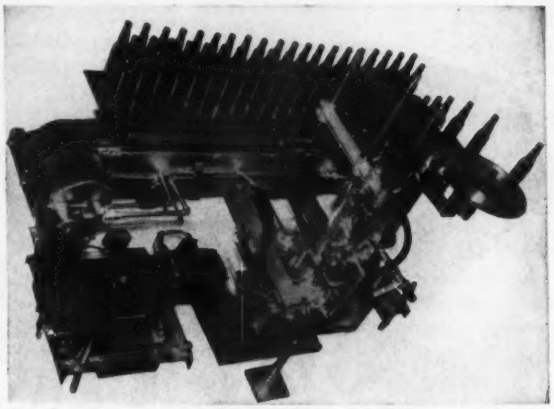

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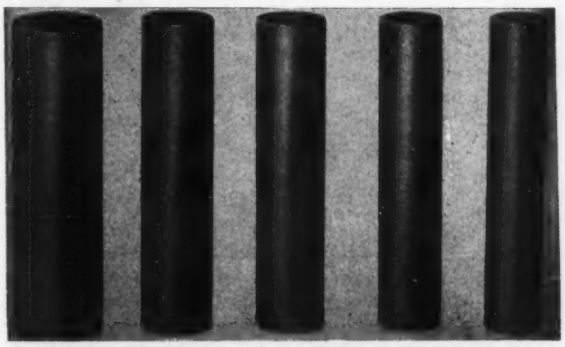

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INNIS, SPEIDEN ACQUIRES CHEMICAL COMPANY

Innis, Speiden & Company has announced the acquisition as a wholly-owned subsidiary the E. S. Browning Company, Inc. of California. The Browning company represents a large number of chemical manufacturers and will continue to operate under its own name. It will, however sell, in addition to its own line, all of Innis, Speiden's chemicals, gums, waxes and insecticides.

Edgar S. Browning will remain as President and General Manager of the California firm. E. A. Smith, formerly with Innis, Speiden in New York as head of the gum department has joined the Browning organization and will coordinate the activities of the two companies.

PENNSYLVANIA CERAMICS ASSOCIATION TO HOLD ANNUAL SPRING MEETING

The Fourth Annual Spring Meeting of the Pennsylvania Ceramics Association, Inc., will be held at the Mineral Industries Building at Pennsylvania State College June 10 and 11.

As on previous occasions, the two-day session will include a Board of Directors meeting, general business meeting, technical sessions, evening banquet and special events for the lady guests of attending members.

• The 37th National Safety Congress and Exposition will be held October 24-28, 1949 at Chicago, Illinois. Sessions scheduled cover industrial safety, traffic safety, and commercial vehicle, school, farm and home safety.

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